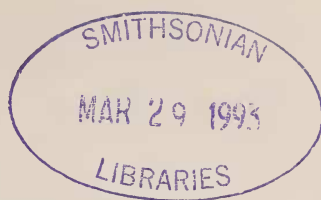


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THEILE, J. 1910. Mollusca. B. Polyplacophora, Gastropoda marina, Bivalvia. In: SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika ausgeführt in den Jahren 1903–1905* 4 (15). *Denkschriften der medizinisch-naturwissenschaftlichen Gesellschaft zu Jena* 16: 269–270.

(continued inside back cover)

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CRETACEOUS FAUNAS FROM ZULULAND
AND NATAL, SOUTH AFRICA.
THE HETEROMORPH AMMONITE GENUS
EUBACULITES SPATH, 1926

By

HERBERT CHRISTIAN KLINGER
&
WILLIAM JAMES KENNEDY

Cape Town

Kaapstad

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SOUTH AFRICA.
THE HETEROMORPH AMMONITE GENUS *EUBACULITES* SPATH, 1926

By

HERBERT CHRISTIAN KLINGER

Department of Invertebrate Palaeontology, South African Museum, Cape Town

&

WILLIAM JAMES KENNEDY

Geological Collections, University Museum, Oxford

(With 57 figures)

[MS accepted 27 May 1991]

ABSTRACT

The taxonomy of the heteromorph ammonite genus *Eubaculites* Spath, 1926 (family Baculitidae), is reviewed and the five most important species, *Eubaculites carinatus* (Morton, 1834), *E. labyrinthicus* (Morton, 1834), *E. vagina* (Forbes, 1846), *E. simplex* (Kossmat, 1895) and *E. latecarinatus* (Brunnschweiler, 1966), are described.

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INTRODUCTION

The genus *Eubaculites* Spath, 1926, is a prominent member of the ammonite fauna of the Zululand Maastrichtian, and is the dominant ammonite in terms of both biomass and numbers of individuals at certain levels in both the Lower and Upper Maastrichtian in parts of Zululand, Chile, Western Australia, and the U. S. Gulf Coast region. Although unknown in Antarctica, the U. S. Western Interior, North and West Africa, Greenland, Asia, Japan, and the Middle East, its otherwise wide distribution shows it to have been one of the most important Maastrichtian heteromorphs. The five best known species,

Eubaculites carinatus (Morton, 1834), *Eubaculites labyrinthicus* (Morton, 1834), *Eubaculites vagina* (Forbes, 1846), *Eubaculites simplex* (Kossmat, 1895), and *Eubaculites latecarinatus* (Brunnschweiler, 1966), are described and discussed below.

LOCATION OF SPECIMENS

The following abbreviations are used to indicate the location of specimens mentioned in the text:

AMNH	American Museum of Natural History, New York
ANSP	Academy of Natural Sciences, Philadelphia
BMNH	Natural History Museum, London
GSI	Geological Survey of India, Calcutta
OUM	Oxford University Museum
SAM	South African Museum, Cape Town
SAS	South African Geological Survey, Pretoria.

FIELD LOCALITIES

Details of field localities are given by Kennedy & Klinger (1975); further descriptions of these localities are deposited in the Department of Palaeontology, Natural History Museum, London, Geological Survey of South Africa, Pretoria, and Department of Invertebrate Palaeontology, South African Museum, Cape Town.

DIMENSIONS OF SPECIMENS

All dimensions are given in millimetres. Wb = whorl breadth; Wh = whorl height. The term 'rib index' means the number of ribs present in a distance equal to the whorl height at the middle of the interval measured. Taper index is:

$$\frac{\text{Larger whorl height} - \text{smaller whorl height}}{\text{Distance between measurements}} \times 100$$

SUTURE TERMINOLOGY

The suture terminology of Wedekind (1916), reviewed by Kullmann & Wiedmann (1970), is followed here: I = internal lobe, U = umbilical lobe, L = lateral lobe, E = external lobe.

SYSTEMATIC PALAEOLOGY

- Phylum MOLLUSCA Cuvier, 1797
- Class CEPHALOPODA Cuvier, 1797
- Order AMMONOIDEA Zittel, 1884
- Suborder ANCYLOCERATINA Wiedmann, 1966
- Superfamily TURRILITACEAE Gill, 1871

Family *Baculitidae* Gill, 1871Genus *Eubaculites* Spath, 1926

(= *Giralites* Brunnschweiler, 1966; *Cardabites* Brunnschweiler, 1966;
Eubaculiceras Brunnschweiler, 1966)

Type species. Baculites vagina Forbes var. *ootacodensis* Stoliczka, 1866: 199, pl. 90 (fig. 14), by the original designation of Spath (1926: 80) (= *Baculites labyrinthicus* Morton, 1834: 44, pl. 13 (fig. 10)).

Diagnosis

Curved or straight baculitids with pyriform whorl section in adult stage; length may exceed 1 m. Dorsum flat to rounded, venter fastigate or with a tabulate siphonal keel, the edges of which are predominantly sharp but subrounded in some. Siphonal keel smooth, ribbed or crenulated. In juveniles, the whorl section may be ovoid, lacking a tabulate or fastigate venter. Venter generally changes from fastigate to keeled, with subrounded to tabulate top during ontogeny; in some it remains fastigate throughout. Development of flank ornament variable; growth lines only, crescentic ribs, or up to two distinct rows of tubercles. Ribs may extend to dorsolateral or ventrolateral region. Aperture apparently simple, with ventral rostrum and sinuous lateral indentation. Suture with plump, finely incised saddles and lobes and phylloid elements in some saddles.

Discussion

The genus *Eubaculites* was introduced in characteristically brief fashion by Spath (1926: 80) as: '*Eubaculites* gen. nov. for the carinate forms of the group of *E. vagina* (Forbes) and *E. ootacodensis* Stoliczka sp. (Kossmat, 'Unters. Südind. Kreideform. Beitr. Pal. Österr.-Ung., vol. ix, 1895, p. 157, pl. xix, figs 15a, b genotype).' Wright (1957: L218) was the first to provide a diagnosis of *Eubaculites*: 'Section pear-shaped, with flat venter; ribs normally faint towards venter but on inner part form prominent long curved bullae; row of lower lateral tubercles may be present. Suture with plump, minutely frilled elements.'

Matsumoto (1959) described a limited *Eubaculites* fauna from California, and essentially followed Wright (1957) in his interpretation of the genus; however, he used the term 'tabulate ventral keel' instead of 'flat venter', because he believed *Eubaculites* could be derived from keeled baculitid species such as *Baculites occidentalis*.

Subsequent descriptions of eubaculitid faunas from various regions, e.g. Western Australia (Brunnschweiler 1966), Zululand, South Africa (Klinger 1976), Argentina (Riccardi 1974), Chile (Hünicken & Covacevich 1975; Stinnesbeck 1986), the Netherlands (Kennedy 1986c), Austria (Kennedy & Summesberger 1986), and southern France (Kennedy 1986a), have differed considerably in their interpretation of the genus—to the extent that Brunnschweiler placed it in a separate subfamily, *Eubaculitinae*, in which he recognized four genera.

It is necessary to look at the genus in terms of the type species. Kennedy (1986c: 193) pointed out that Spath's 'genotype' (type species) is a species and not an individual. *Eubaculites ootacodensis* is thus the type species of *Eubaculites*. The lectotype of *E. ootacodensis* by subsequent designation of Kennedy (1986c: 193) is the original of Stoliczka (1866, pl. 90 (fig. 14)) from the Maastrichtian Arrialoor Group of

South India, whereas (as shown below) *E. ootacodensis* is a synonym of *Eubaculites labyrinthicus* (Morton, 1834).

Because Spath (1926) did not provide a diagnosis of *Eubaculites*, it is possible to decide on the limit of his generic concept only on the basis of species he referred to it. That he included *Eubaculites vagina* of Forbes (1846a), the type material of which was available to him for study, shows that the distinctive feature of this species—a broad tabulate venter and bituberculate ribbed flanks—were encompassed. That he cited plate 19 (fig 15) of Kossmat (1895) as a reference to the species, rather than the original figure, is unfortunate, as this figure is of an incomplete specimen, lacking the critical features of the venter (Fig. 7F–H). It is, however, a topotype of the species, likely to be conspecific with *E. ootacodensis* of Stoliczka (= *Eubaculites labyrinthicus* (Morton, 1834)) and thus characterized by binodose, ribbed flanks and a fastigiate venter.

In describing the Maastrichtian faunas from Western Australia, Spath (1940: 49) referred Kossmat's *Baculites vagina* var. *simplex* (1895: 156(60), pl. 19(5) (figs 13a–b, 14a–cb)) to *Eubaculites*, but nevertheless separated it from *Eubaculites vagina* '... because it is a passage-form between *Eubaculites* and *Baculites* s.s.'—thus including forms with both tabulate and fastigiate venters in *Eubaculites*. Later (1953: 20), he seemed to regard possession of a tabulate venter as an essential feature: 'The true *Eubaculites vagina* (Forbes) which I discussed recently (1940, p. 48) has a perfectly tabulate, not a sharpened, venter already at 10 mm (long diameter) . . . so that *Baculites cazadorianus* is neither a *Eubaculites* nor a variety of *E. vagina*.' In the same article (1953: 46), he also referred to *Baculites vagina* var. *simplex* Kossmat as *E.(?) simplex*. Both Wright (1957: L218) and Matsumoto (1959: 166) emphasized the tabulate shape of the venter of *Eubaculites*. Klinger (1976: 90) noted that Stoliczka's figure of *E. ootacodensis* showed a fastigiate venter, although his description may have been based in part on specimens with tabulate venters ('. . . the siphuncle often lies nearer to one edge than to the other; this, however, is not constant in all specimens'—Stoliczka 1866: 199).

Brunnschweiler (1966) described (amongst other heteromorphs) a eubaculitid assemblage of about 200 specimens from the Miria Marl of Western Australia—until then the most extensive collection of the genus described. This included forms with tabulate and fastigiate venter, ribbed and smooth forms, and inflated and compressed forms. These he referred to a new subfamily Eubaculitinae and four genera. This subfamily was distinguished from Baculitinae (Brunnschweiler 1966: 24) for those forms 'with a ventral keel which appears in very early growth stages. The keel is either acute or tabulate, never rounded.'

Brunnschweiler's criteria for recognition of the four genera he referred to the subfamily Eubaculitinae were as follows:

Genus *Eubaculites*, type species *E. ootacodensis* (Stoliczka). This genus was restricted to those costate forms that are truly similar to the type species in cross-section and shape of the keel.

Genus *Giralites* Brunnschweiler, 1966, type species *Giralites latecarinatus* Brunnschweiler, 1966. The genus included non-costate species in which the Wh : Wb ratio is less than 1.8 : 1.

Genus *Eubaculiceras*, type species *Eubaculiceras compressum* Brunnschweiler, 1966. This included ribbed species with a very compressed whorl section and a Wh : Wb ratio of 2 : 1 or more.

Genus *Cardabites* Brunnshweiler, 1966, type species *Cardabites tabulatus* Brunnshweiler, 1966. This is a non-costate genus with a very compressed whorl section with a Wh : Wb ratio of 2 : 1 or more.

Klinger (1976: 83–84) regarded all these as synonyms of *Eubaculites* and, for stratigraphic purposes, recognized four species groups based primarily on lateral ornament and secondarily on compression of the whorl section, although admitting that the divisions were arbitrary and that the groups were connected by transitions:

1. *Eubaculites* gr. ex. *vagina* (Forbes) with pyriform whorl shape, Wh : Wb less than 2 : 1, ornament consists of tubercles at mid-flank and at dorsolateral edge.
2. *Eubaculites* gr. ex. *ootacodensis* (Stoliczka). Whorl section as in *E. vagina*; lateral ornament consisting of strong crescentic ribs. Venter tabulate or fastigate.
3. *Eubaculites* gr. ex. *latecarinatus* (Brunnshweiler). Whorl section as above, but flanks devoid of all ornament.
4. *Eubaculites* gr. ex. *compressum* (Brunnshweiler). Whorl section strongly compressed; Wh : Wb, 2 : 1 or more. Lateral ornament, if present, very weak. Venter fastigate or tabulate.

Kennedy (1986a: 1015; 1986c: 194) and Kennedy & Summesberger (1986: 197) accepted Klinger's (1976) species groups with some modifications, but considered the shape of the ventral keel to be of major significance. Kennedy (1986a: 1015, 1986c: 194) recognized three species groups:

1. Species with fastigate venter and flattened dorsum, ribbed or smooth, e.g. *Baculites ootacodensis* Stoliczka, 1866, *Baculites vagina* var. *simplex* Kossmat, 1895, *Baculites rioturbioensis* Hünicken, 1965, *Eubaculiceras fastigiatum* Brunnshweiler, 1966, *Cardabites scimitar* Brunnshweiler, 1966, and *Baculites argentinicus* Weaver, 1927—the last named a *nomen dubium* and possibly a corroded fragment of *B. rioturbioensis*.
2. Species with tabulate venter, flattened dorsum, dorsolateral and dorsal tubercles, some individuals smooth, e.g. *Baculites vagina* Forbes, 1846, and *Baculites ornatus* d'Orbigny, 1847.
3. Species with tabulate venter and flattened dorsum generally ornamented by flank ribs, some individuals may be smooth, e.g. *Baculites lyelli* d'Orbigny, 1847, *Eubaculites kossmati* Brunnshweiler, 1966, *Eubaculites multicostatus* Brunnshweiler, 1966, *Giralites latecarinatus* Brunnshweiler, 1966, *Giralites quadrisulcatus* Brunnshweiler, 1966, *Eubaculiceras compressum* Brunnshweiler, 1966, and *Cardabites tabulatus* Brunnshweiler, 1966.

Stinnesbeck (1986) discussed *Eubaculites lyelli* from Quiriquina, Chile, on the basis of several hundred specimens; he concluded that transitions to *E. latecarinatus*, *E. compressum* and *E. ootacodensis* occur in his material (of *E. lyelli*) but these cannot, as yet, be used for stratigraphic purposes. As far as we can ascertain, no typical examples of *E. latecarinatus*, *E. compressum* or *E. ootacodensis* occur at Quiriquina.

A subsequent unpublished revision of North American *Eubaculites* by Kennedy & Cobban (in preparation) revealed that the prior name for *Baculites lyelli* of d'Orbigny (1847) was *Baculites carinatus* (Morton, 1834), and that for *Baculites vagina* var. *ootacodensis* of Stoliczka (1866) was *Baculites labyrinthicus* of Morton (1834), as described below.

Henderson *et al.* (1992) revised the *Eubaculites* of the Miria Formation and underlying phosphate horizon at the top of the Korojong Calcarenite in the Carnarvon Basin, Western Australia. They recognized *Eubaculites latecarinatus* (with *Giralites quadrisulcatus* Brunnschweiler (1966) and *Eubaculites ambindensis* of Collignon (1971) as synonyms) as the oldest species, present only in the phosphatic nodule bed at the top of the Korojong Calcarenite. The overlying Miria Formation yielded two species: *Eubaculites carinatus* (of which *Eubaculites ootacodensis* of Brunnschweiler (1966, *non* Kossmat), *E. vagina* of Brunnschweiler (1966, *non* Forbes), and *E. kossmati* and *E. multicostatus* are synonyms) and *E. simplex* (of which *Eubaculiceras compressum*, *E. fastigiatum*, *Cardabites tabulatus* and *C. scimitar* are synonyms). They also showed *E. simplex* to include individuals with both tabulate and fastigate venter through ontogeny, as well as those with an initially fastigate venter that develop a tabulate venter subsequently.

Baculites occidentalis Meek, 1862 (see e.g. Usher 1952: 98, pl. 28 (fig. 1), pl. 31 (fig. 19), text-fig. 4; Matsumoto 1959: 150, pl. 35 (figs 2a–d, 3a–d), pl. 36 (fig. 1a–d), pl. 41 (fig. 1a–d), pl. 42 (fig. 1a–c, 2a–c), text-figs 64, 65a–b, 66, 67–71; Obata & Matsumoto *in* Matsumoto & Obata 1963: 82, pl. 23 (fig. 3), pl. 25 (fig. 1), pl. 26 (figs 1–3), pl. 27 (figs 2–5, 8), text-figs 172–186), has an indistinct siphonal keel with rounded edges, and was regarded by Matsumoto (1959: 154) as an intermediate stage between *Baculites* and *Eubaculites*. We here tentatively regard it as an early form of *Eubaculites*.

Baculites regina Obata & Matsumoto (*in* Matsumoto & Obata 1963: 85, pl. 22 (figs 3–6), pl. 23 (figs 1–2), pl. 24 (figs 1–5), pl. 25 (figs 3–5), pl. 27 (figs 1, 6–7, 9), text-figs 191–196, 200–214) from the Campanian of Honshu, was compared to *Eubaculites* by Obata & Matsumoto (*in* Matsumoto & Obata 1963: 90), because of its flattened dorsum, subangular dorsal edges and differentiation of lateral ornament. However, it lacks a tabulate siphonal keel and is better regarded as a lateral offshoot of *Eubaculites occidentalis* rather than in the main line of descent to *Eubaculites*, according to Obata & Matsumoto (*in* Matsumoto & Obata 1963: 91).

Baculites lomaensis Anderson (1958: 191, pl. 48 (figs 5–6)) was regarded as being related to *Eubaculites vagina* by Anderson, but it appears that this opinion was based mainly on stratigraphic grounds. *Baculites lomaensis* lacks a tabulate siphonal keel and has a suture line similar to early true *Baculites*.

We here recognize the following species of *Eubaculites*, synonyms of the most important which are given below: *Eubaculites carinatus* (Morton, 1834), *Eubaculites labyrinthicus* (Morton, 1834), *Eubaculites vagina* (Forbes, 1846), *Eubaculites latecarinatus* (Brunnschweiler, 1966), *Eubaculites simplex* (Kossmat, 1895), and *Eubaculites occidentalis* (Meek, 1862). *Baculites binodosus* Noetling, 1897, and *Baculites rioturbioensis*, Hünicken, 1965, may be further valid species.

Occurrence

Where well dated, *Eubaculites* is typically Maastrichtian, ranging throughout most of the stage; *Eubaculites occidentalis* may appear in the Upper Campanian (for the basis of a Campanian date, see Ward 1978a, 1978b). The evolutionary origin of the genus is not clear; it probably lies in the group of *Baculites chicoensis* Trask, 1856 (see Matsumoto 1959: 145, pl. 36 (fig. 2), pl. 37 (fig. 1), text-figs 59a–d, 60a–b, 61a–b, 62a–b, 63a–b), from the Lower Campanian of California and British Columbia, but similarities in ornament between *E. carinatus* and *E. labyrinthicus*, and *Baculites* sp. (nov.?) cf.

B. aquilaensis Reeside (in Collignon, 1970: 81, pl. 639 (fig. 8, 8a); see Fig. 57) from the Upper Campanian of Madagascar and *Baculites vanhoepeni* from the Campanian of Zululand, are striking. However, this probably is due to homoeomorphous development only. Unfortunately, the phylogeny of the genus is difficult to elucidate, mainly because of the very poor level of inter-regional correlation of the Maastrichtian at the present time, this difficulty also extending to the definition of the base of the stage (Birkelund *et al.* 1984) and division into substages. The present state of knowledge of *Eubaculites* in its main areas of occurrence is discussed below.

South Africa. Details of the distribution of *Eubaculites* in Zululand were given by Klingler (1976). These are emended here on the basis of new collections and the taxonomic revision given below. Specimens previously referred to *E. ootacodensis* are *E. carinatus*, as are some specimens previously referred to *E. vagina*.

Stratigraphic distribution is as follows: *Eubaculites labyrinthicus*—Maastrichtian II; *Eubaculites carinatus*—Maastrichtian a, Maastrichtian I–II; *Eubaculites latecarinatus*—Maastrichtian ?a, Maastrichtian I–?II; *Eubaculites simplex*—Maastrichtian I–II; *Eubaculites vagina* (?)—Maastrichtian I.

Eubaculites carinatus is most abundant in Maastrichtian I–II, but occurs as early as Maastrichtian a (ex Campanian IV of Kennedy & Klingler 1975). *Eubaculites latecarinatus* is very abundant in Maastrichtian I and possibly persists to Maastrichtian II. Off-shore data (Klingler *et al.* 1980) suggested it may already occur as early as Maastrichtian a. *Eubaculites simplex* is known from Maastrichtian I–II. Typical binodose adult *E. vagina* are not known from Zululand—possible *E. vagina* (herein interpreted as *E. labyrinthicus*) are known from Maastrichtian I.

Mozambique. Material described by Crick (1924) is poorly preserved, but is here identified as follows: *Baculites sheringomensis* = *Eubaculites carinatus*; *Baculites vagina* var. *ootacodensis* = *Eubaculites carinatus*; and *Baculites vagina* var. *simplex* = *Eubaculites carinatus*.

Chile. The Quiriquina Formation has yielded only one species, *E. carinatus*, which is also the most common ammonite there (Fig. 37) (cf. Hünicken & Covacevich 1975; Stinnesbeck 1986). Stinnesbeck (1986: 207) claimed that transitions to *E. latecarinatus*, *E. compressum* and *E. ootacodensis* are present in his collections but stated that these do not, as yet, have any stratigraphic significance (*E. ornatus* d'Orbigny, 1847, is most probably a specimen of *E. vagina* from Pondicherry, India). Stinnesbeck (1986) dated the Zone of *Eubaculites lyelli* (= *E. carinatus*) as upper Lower Maastrichtian to Upper Maastrichtian.

Argentina. *Eubaculites carinatus* is relatively common in the Neuquén Basin of northern Patagonia. Riccardi (1974) dated it as Lower–Middle Maastrichtian.

Weaver (1927) described *Baculites argentinicus* from the Cerro Huantraico in Neuquén Province. This is based on two fragmentary specimens (see Olsson 1944: 105 (263)) and has generally been interpreted as a *nomen dubium* (cf. Riccardi 1974: 397; Kennedy 1986a: 1015; 1986c: 194). Camacho (1967) recorded this species from Paso del Sapo on the Chubut River, and regarded it as a *Eubaculites*. It belongs to the group of *E. simplex* in having a fastigiate venter. Camacho (1968: 328, pl. 3 (figs 5a–b, 6)) recorded a baculitid with a fastigiate venter, and a true *Eubaculites* with tabulate venter from this area. Subsequent work by M. Uliana (in Riccardi 1974: 396) has yielded *Baculites rioturbioensis*.

Baculites argentinicus and *B. rioturbioensis* appear to be synonyms, and are contemporaries of *Eubaculites*.

Baculites rioturbioensis was described from the 'Yacimiento Rio Turbio', Santa Cruz Province in the Austral Basin of Patagonia, near the boundary with Argentina and Chile. Hünicken (1965: 63) dated it as uppermost Campanian to basal Maastriichtian. *Baculites rioturbioensis* has a flat dorsum, fastigiate venter, and broad undulating lateral ribs; it belongs to the group of *E. simplex*. A ribbed specimen of *Eubaculites* was described from a borehole in Santa Cruz Province by Garcia & Camacho (1965: 72, pl. 1 (fig. 4)).

There may thus be an older *Eubaculites carinatus*-*Baculites rioturbioensis* assemblage and a younger one with *E. carinatus* alone.

Western Australia. Based on the work of Henderson & McNamara (1985) and Henderson *et al.* (1992), the following sequence can be recognized in the Carnarvon Basin. The oldest assemblage with *Eubaculites* comes from the nodule bed at the top of the Korojong Calcarenite (12–20 cm), with *Eubaculites latecarinatus*, *Nostoceras (N.) attenuatus* Brunnschweiler, 1966, *N. (N.) fischeri* Brunnschweiler, 1966, and *Gunnarites kalika* (Stoliczka, 1865). The lower part (75–150 cm thick) of the overlying Miria Formation yields *Eubaculites simplex* and rare non-heteromorphs, including *Phyllopachyceras forbesianum* (d'Orbigny, 1850), *Pachydiscus jacquoti australis* Henderson & McNamara, 1985, *Gunnarites kalika*, *Neophylloceras surya* (Forbes, 1846) and *Gaudryceras kayei* (Forbes, 1846). The upper part of the Miria Formation (45–50 cm) yields abundant *Eubaculites carinatus*, common *Diplomoceras cylindracum* (Defrance, 1816) and *Glyptoxoceras rugatum* (Forbes, 1846), rare *Baculites lechitides* Brunnschweiler, 1966, and 22 species of non-heteromorphs described by Henderson & McNamara (1985). The succeeding Palaeocene Boongarooda Greensand yields reworked *Eubaculites carinatus*.

South India. The oldest occurrence of *Eubaculites* in South India is that of *Eubaculites labyrinthicus* (as *E. vagina* var. *ootacodensis*) and *E. simplex* in the white sandstone of the Arrialoor Group north of Ootacod, near Arrialoor, which also yielded *Pachydiscus tweenianus* (Stoliczka, 1865) and *Anapachydiscus arrialoorensis* (Stoliczka, 1865), and is said to yield *Hauericeras gardeni* (Baily, 1955). (*Pachydiscus preegertoni* Collignon, 1952, was also illustrated from an unspecified horizon near Arrialoor as *Ammonites eger-tonianus* Forbes of Stoliczka 1865, pl. 5 (figs 1, 1a); *vide* Matsumoto *et al.* 1986: 5.)

Much younger are records from the Valudavur Formation of Pondicherry. *Eubaculites vagina* comes from the *Anisoceras* beds of various authors and is probably from a horizon equivalent to the lower part of the Upper Maastriichtian *Abathomphalus mayaroensis* (planktonic foraminiferan) Zone (Rajagoplan 1965; Govindan 1972). *Eubaculites lyelli* probably occurs at an even higher horizon, the lower part of the *Trigonarca* Beds of Kossmat, horizon D of Warth (1895) (e.g. *Baculites vagina* var. *ootacodensis* Stoliczka of Kossmat 1895, pl. 19(5) (fig. 16)).

Madagascar. The records from Madagascar (Collignon 1971) indicate the presence of *E. vagina*, *E. labyrinthicus* (as *E. ootacodensis*), *E. simplex* and *E. latecarinatus* (as *Baculites occidentalis* and *E. ambindensis*) at the following localities (horizons): *E. vagina*—localities 504, 671; *E. simplex*—localities 503, 666; *E. latecarinatus*—localities 504, 665–7; and *E. labyrinthicus*—localities 503, 504.

We are unable to place these localities in sequence, but note that *E. vagina*, *E. latecarinatus* and *E. labyrinthicus* co-occur at locality (horizon) 504.

Japan. No typical *Eubaculites* has been recorded, but for doubtful *Baculites occidentalis* and *B. regina* Obata & Matsumoto from uncertain Upper Campanian to lower Maastrichtian of south-west Japan (in Matsumoto & Obata 1963).

United States. The oldest recorded *Eubaculites* is *E. occidentalis*, which occurs in the Upper Campanian–Lower Maastrichtian of California and British Columbia (Matsumoto 1959; Ward 1978a, 1978b). *Eubaculites carinatus* from the presumed Maastrichtian of California was recorded as misidentified *Baculites chicoensis* Gabb (1864 pars) and *Eubaculites ootacodensis* by Matsumoto (1959). In the Gulf Coast region, the Corsicana Formation of north-east Texas yields *Eubaculites carinatus* and is equivalent to the mid-Maastrichtian *Globotruncana gansseri* (planktonic foraminiferan) Zone (Kennedy & Cobban unpublished). The Owl Creek Formation of Missouri and Mississippi yields common *E. carinatus* (Conrad 1858; Stephenson 1955) and is referred to the upper part of the *G. gansseri* zone by C. C. Smith (pers. comm. 1990). The Maastrichtian Prairie Bluff Chalk in Alabama is the source of the type material of *E. carinatus* and *E. labyrinthicus*, but these occurrences are difficult to date precisely as they are from phosphatic layers that include elements from more than one horizon in the Maastrichtian, at least in some places.

In New Jersey, *E. labyrinthicus* occurs in the Maastrichtian middle part of Navesink Formation, and *E. carinatus* has been found reworked into the base of the succeeding Palaeocene.

Europe. There is a well-substantiated belemnite zonation from the White Chalk of north-west Europe, into which the scattered occurrences of *Eubaculites carinatus* can be placed. This zonation is:

ZONE		
Upper Maastrichtian	{	<i>Belemnella casimirovensis</i>
	{	<i>Belemnitella junior</i>
Lower Maastrichtian	{	<i>Belemnella occidentalis</i>
	{	<i>Belemnella lanceolata</i>

Eubaculites carinatus first appears at Neuberg, Steiermark, Austria, at a horizon equivalent to the lower part of the *Belemnella occidentalis* Zone (Kennedy & Summesberger 1986: 200), that is to say, somewhere in the *Globotruncana gansseri* (planktonic foram) Zone. The last appearance of *E. carinatus* is in the Petites-Pyrénées of south-eastern France (Kennedy *et al.* 1986), where the species occurs with forms of *Hoploscaphites constrictus* that indicate the *Belemnella casimirovensis* Zone, and foraminifera indicating the upper part of the *Abathomphalus mayaroensis* (planktonic foraminiferan) Zone. There is also a mass occurrence of this species in the *A. mayaroensis* Zone, approximately 40 m below the base of the Palaeocene at Hendaye (Pyrénées Atlantiques), France. A specimen from the Maastricht area (Kennedy 1986c: 195, pl. 27 (figs 5–8)) is from either the upper part of the *B. junior* Zone or the lower part of the *B. casimirovensis* Zone.

It is difficult to determine absolute ranges for *Eubaculites* species from these data, because of difficulties in long-distance correlation. Using Upper and Lower Maastrichtian

in a north-west European sense, *E. carinatus* is seen to be long-ranging, from middle Lower to upper Upper Maastrichtian. *Eubaculites vagina* is probably lower Upper Maastrichtian, overlapping with *E. carinatus*, but not occurring with it in the Valudavur Formation in South India.

Evidence from Western Australia suggests *E. simplex* to be Upper Maastrichtian; that it is older than *E. vagina* in South India might suggest lower Upper Maastrichtian. *Eubaculites latecarinatus* is older than *E. simplex* in Western Australia, whereas *E. labyrinthicus* occurs with *E. carinatus* and *E. latecarinatus* in Maastrichtian II in Zululand.

The succession of *Eubaculites* may thus be:

E. carinatus (youngest)

E. carinatus, *E. vagina*

E. carinatus, *E. simplex* (?plus *E. labyrinthicus*)

E. carinatus, *E. labyrinthicus*, *E. latecarinatus*

E. carinatus

E. occidentalis (oldest).

Eubaculites labyrinthicus (Morton, 1834)

Figs 1–6, 7F–H, 36A–D, 52A–C

Baculites labyrinthicus Morton, 1834: 44, pl. 13 (fig. 10).

Baculites vagina Forbes var. *Ootacodensis* Stoliczka, 1866: 199, pl. 90 (fig. 14) (*non* fig. 15).

Baculites vagina var. *Ootacodensis* Stoliczka: Kossmat, 1895: 157, pl. 19(5) (?fig. 15) (*non* fig. 16 =

E. carinatus). Cottreau, 1922: 180(72), pl. 9(17) (fig. 11–11b). Diener, 1925: 63 (pars).

Baculites vagina Forbes: Spengler, 1923: 54, pl. 4 (fig. 9). Besairié, 1930: 222, pl. 26 (figs 12–13).

non Eubaculites ootacodensis (Stoliczka): Spath, 1940: 49, pl. 1 (fig. 3), text-fig. 1b (= *E. carinatus*).

non Eubaculites ootacodensis (Stoliczka): Wright, 1957: L218, text-figs 245, 246a–c (= *E. carinatus*).

non Eubaculites ootacodensis (Stoliczka): Matsumoto, 1959: 166, pl. 43 (fig. 6), pl. 44 (figs 1–3), text-figs 84–85 (= *E. carinatus*).

non Eubaculites ootacodensis (Stoliczka): Brunnschweiler, 1966: 27, pl. 1 (figs 9–14), text-figs 9–11 (= *E. carinatus*).

?*Eubaculites* sp. Leanza, 1967: 55, pl. 1 (figs 6–7).

Baculites simplex Kossmat: Collignon, 1971: 15, pl. 645 (figs 2388–2389).

non Eubaculites ootacodensis Stol.: Collignon, 1971: 18, pl. 646 (fig. 2395) (? = *E. carinatus*).

non Eubaculites ootacodensis (Stoliczka): Riccardi, 1974: 388, pl. 1 (figs 1–7), pl. 2 (figs 1–4, 6), pl. 3 (figs 1–6), pl. 4 (figs 1–7), text-fig. 2 (= *E. carinatus*).

Eubaculites ootacodensis (Stoliczka): Klinger, 1976: 90 (pars) pl. 39 (fig. 3 only) (*non* fig. 1); *non* pl. 41 (figs 1–2), pl. 42 (figs 3, 8), text-fig. 11c (= *E. carinatus*). Kennedy, 1986c: 194 (pars).

Eubaculites labyrinthicus (Morton): Kennedy & Henderson, 1992: 716, text-fig. 5D–K.

Types

There are two syntypes (Fig. 1). The original of Morton (1834, pl. 13 (fig. 10)) is ANSP 72868; the second specimen is ANSP 72869. Both are from the Prairie Bluff Chalk of Alabama. The lectotype of *Baculites ootacodensis* is the original of Stoliczka (1866, pl. 90 (fig. 14a–c)) (Fig. 5), GSI 406 and GSI 407 in the Collections of the Geological Survey of India, from 'the white gritty sandstone north of Ootacod, near Arrialoor'.

Material

SAM–PCZ8652 from Bed 3(C) and OUM–KX1828–1833, from Bed 7 (G) at locality 20, Zululand, St Lucia Formation, Maastrichtian I–II.



Fig. 1. *Eubaculites labyrinthicus* (Morton, 1834). A-C. Syntype, ANSP 72868. D-F. Syntype, ANSP 72869. Both from the Prairie Bluff Chalk of Alabama. Collection of the Academy of Natural Sciences of Philadelphia. $\times 1$.

Diagnosis

Whorl section cuneiform, with flattened dorsum and fastigiata venter, lacking siphonal, tabulate keel; lateral ornament consists of two rows of tubercles, linked by ribs of variable strength.

Description

This is a rare species. In addition to the types, we have seen four other fragments from the Prairie Bluff Chalk. All are phosphatic internal moulds; they range from 8,0 mm to 17,5 mm in whorl height. The largest specimen (syntype ANSP 72868), figured by Morton (1834, pl. 13 (fig. 10)), is wholly septate throughout (Fig. 1A-C). The expansion rate is moderate, the whorl section compressed, with intercostal whorl breadth to height ratio 0,58. The dorsum is flattened and barely convex. The dorsolateral margin is narrowly rounded, the dorsal flanks flattened, mid-flank region broadly rounded, ventral flanks flattened and convergent, and the venter fastigiata. Strong nodes, elongated parallel to the length of the shell, perch on the dorsalmost flank, two occurring in a distance equal to the whorl height. A low, broad rib connects the node to a similarly elongated but slightly obliquely aligned mid-lateral tubercle. The mid-lateral tubercles give rise to delicate riblets and striae, also present on the interspaces, and projected forwards to intersect

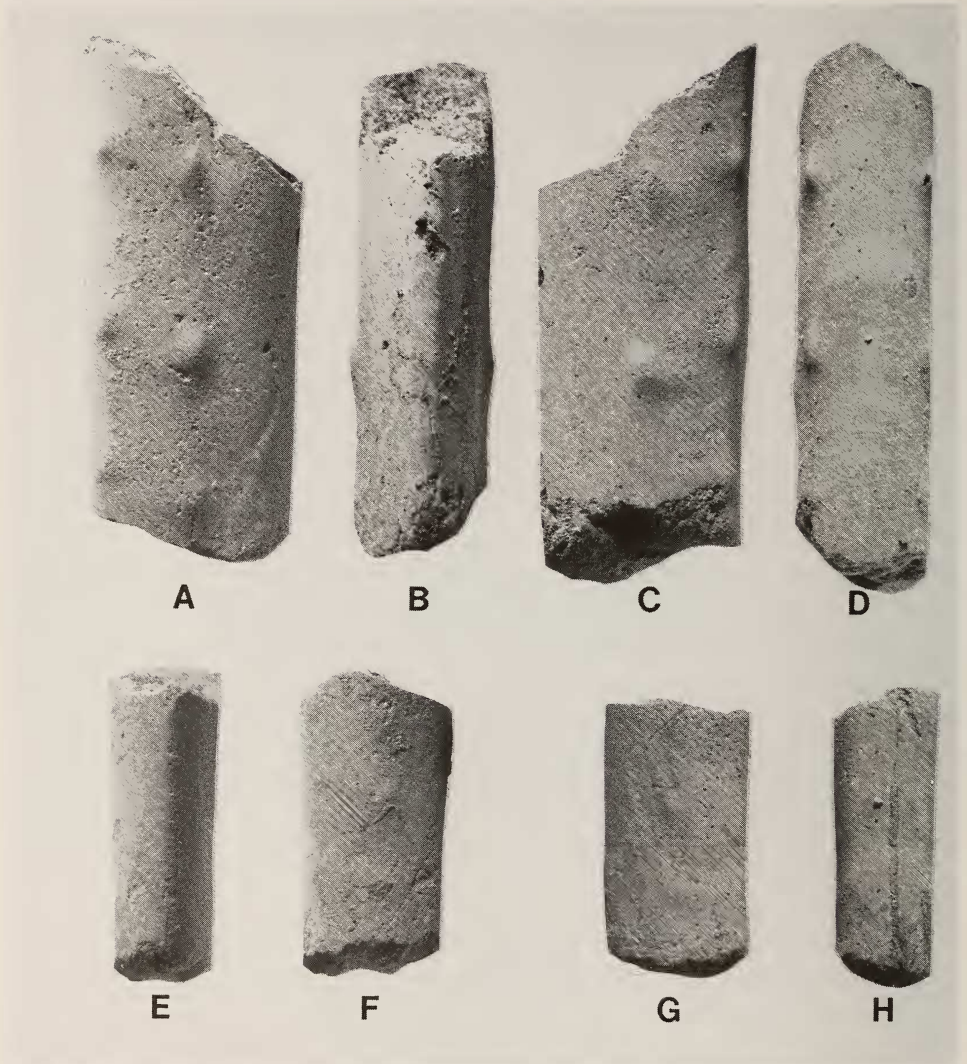


Fig. 2. *Eubaculites labyrinthicus* (Morton, 1834). A-D. OUM KX1831. E-H. OUM KX1832. Both from Bed 7 (G), locality 20, Zululand, St Lucia Formation, Maastrichtian II. Both $\times 2$.

the siphonal line of the mid-venter at an acute angle. The dorsum is decorated by feebly convex ribs and striae. The suture has broad, bifid, rectangular saddles, L/U with variable degree of incision, E/L narrow and bifid, and U broad and bifid.

A cast of the lectotype of *Baculites ootacodensis*, here considered a junior synonym of *E. labyrinthicus*, shows it to be a wholly septate internal mould, 56 mm long (GSI 406, Fig. 5), with a maximum preserved whorl height of 15,5 mm. The intercostal whorl breadth to height ratio is 0,62, the dorsum broad and very feebly convex to flat. The dorsolateral margin is narrowly rounded, the dorsal flanks flattened in intercostal section, the mid-flank region broadly rounded, the ventral flanks flattened, converging to a bluntly

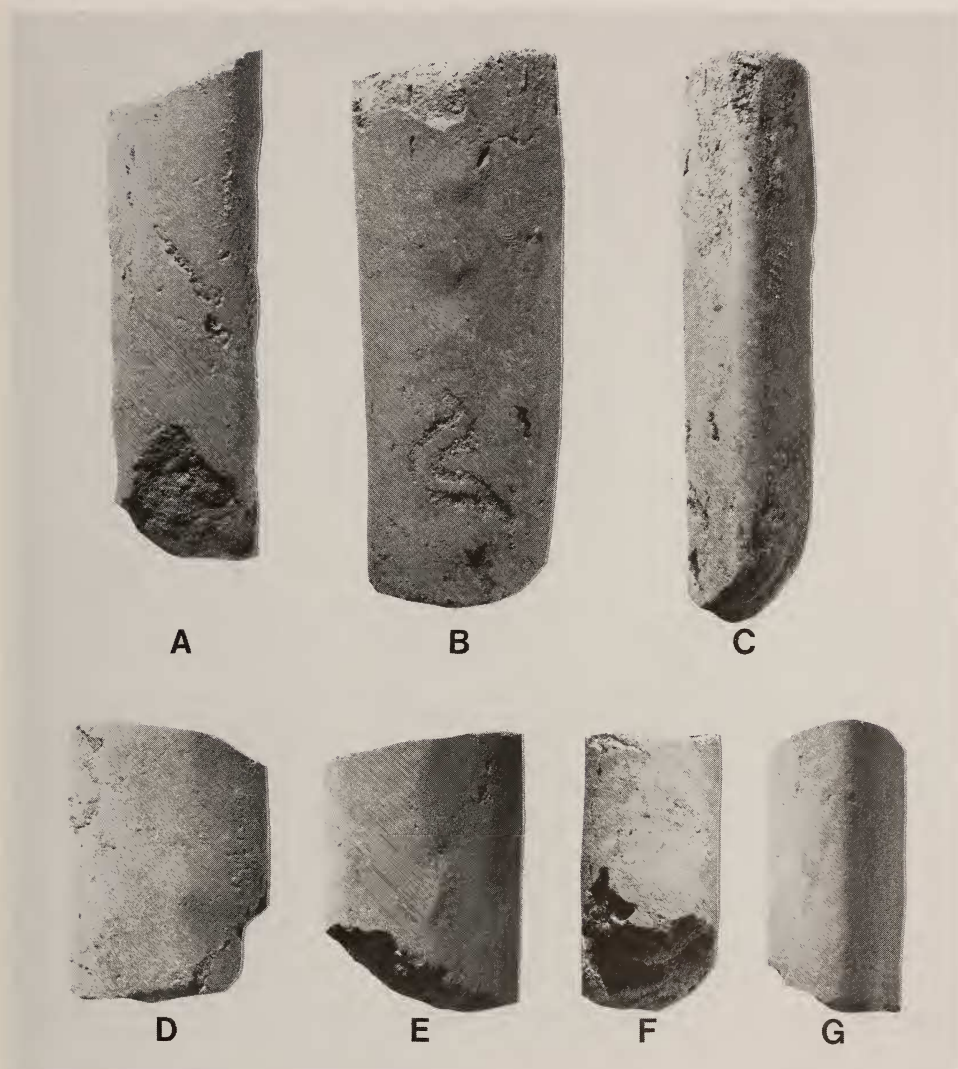


Fig. 3. *Eubaculites labyrinthicus* (Morton, 1834). A-C. OUM KX1830. D-G. OUM KX1829. Both from Bed 7 (G), locality 20, Zululand, St Lucia Formation, Maastrichtian II. Both $\times 2$.

fastigate venter. There are two ribs in a distance equal to the whorl height, parts of four ribs being preserved on the specimen. They begin at small dorsolateral nodes, perched on the dorsolateral margin, are elongated parallel to the length of the shell, and are coarse, transverse and feebly prosiradiate on the inner flank, strengthening into a mid-lateral tubercle that is elongated in a slightly prosiradiate direction. These tubercles give rise to a progressively weakening prosiradiate rib that sweeps forwards and declines before reaching the venter. The flanks are otherwise smooth, but the mid-venter is distinctly crenulated.

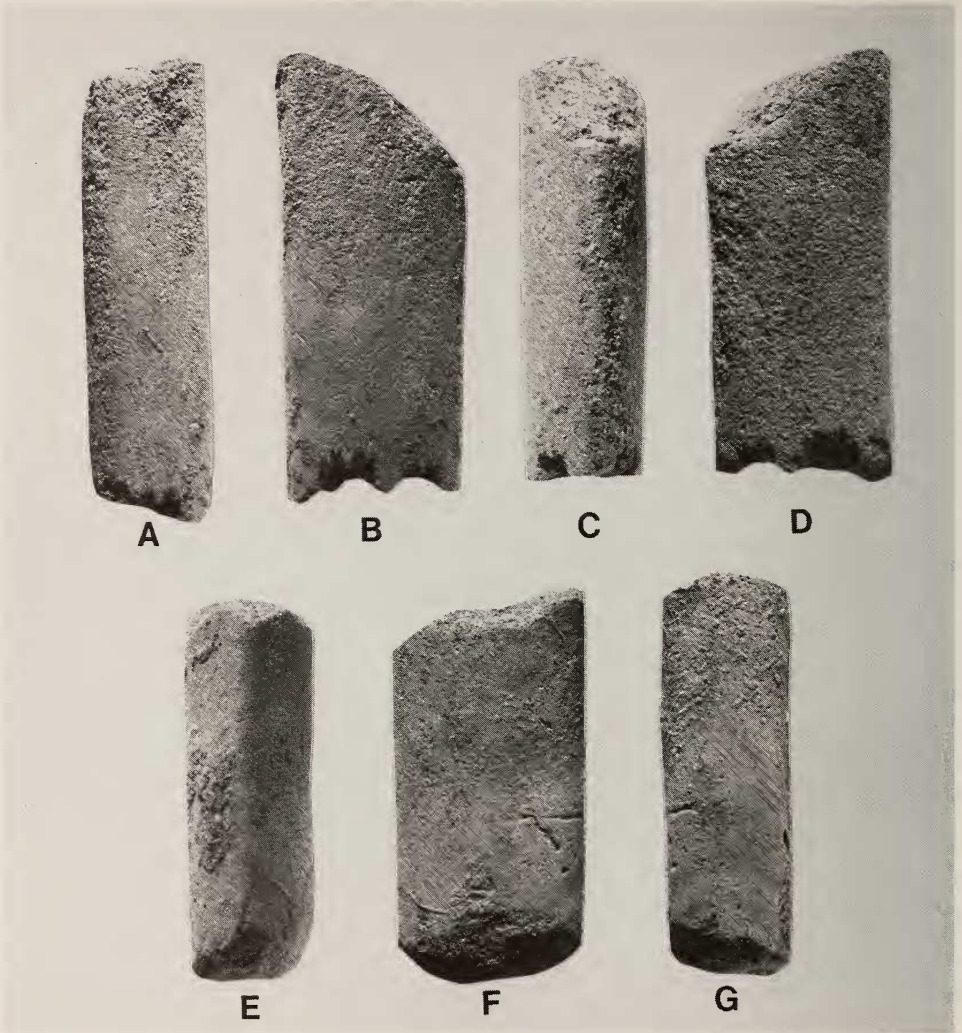


Fig. 4. *Eubaculites labyrinthicus* (Morton, 1834). Smooth variants with fastigate venter, probably of *E. labyrinthicus*. A-D. OUM KX1828. E-G. OUM KX1833. Both from Bed 7 (G) at locality 20, Zululand, St Lucia Formation, Maastrichtian II. Both $\times 2$.

The Zululand specimens referred to the species (Figs 2-4, 52A-C) are all rather small body chambers, with a maximum preserved whorl height of 14,5 mm, and a whorl breadth to height ratio of 0,65. They have weaker ornament than the types of both *Eubaculites labyrinthicus* and *E. ootacodensis*, rather matching specimens from the Prairie Bluff Chalk, such as those shown in Figure 1; in fact, some specimens are nearly smooth (Figs 3-4). Material from Madagascar, here referred to *E. labyrinthicus*, includes specimens larger than any known from the Prairie Bluff Chalk or the Valudavur Formation (e.g. Collignon 1971: 15, pl. 645, (fig. 2388), as *Baculites simplex*—herein Fig. 6; Cottreau, 1922: 180, pl. 9 (fig. 11), as *Baculites vagina* var. *ootacodensis*). In these, lateral

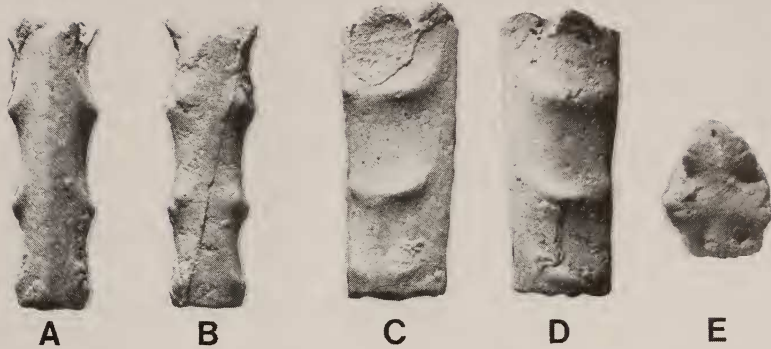


Fig. 5. *Eubaculites labyrinthicus* (Morton, 1834). Cast of lectotype of *E. ootacodensis* (Stoliczka, 1866), the original of Stoliczka, 1866, pl. 90 (fig. 14), from Ootacod. Collection of the Geological Survey of India, no. 406 \times 1.

ornament consists predominantly of prominent crescentic ribs, with little or no sign of development of tubercles. We assume these to be adults of forms with bituberculate ornament in the juvenile stage. Given more material, it may be possible to separate those forms with lateral ribbing only and fastigate venter from those with lateral ribbing, two rows of tubercles and fastigate venter. The relationship of these predominantly ribbed to ribbed and bituberculate forms may be analogous to that of *E. carinatus* to *E. vagina*.

Discussion

Eubaculites labyrinthicus has been a neglected species, but comparison of the type and other material from the Prairie Bluff Chalk with the lectotype of *E. ootacodensis* and the Zululand and Madagascan material referred to the species, show this to be a distinctive form, the combination of predominantly binodose flanks and a fastigate venter distinguishing it from all other species referred to the genus. *Eubaculites vagina* (Forbes, 1846) (Figs 8–20) has binodose flanks, but the type population shows it to have a broad, flat tabulate venter at a size where *E. labyrinthicus* is fastigate. Some variants of *E. carinatus* develop an incipient binodose condition (e.g. Brunnschweiler 1966, text-fig. 11), but the broad, tabulate ventral keel is immediately distinctive.

Eubaculites ootacodensis has been widely misinterpreted. In his original account, Stoliczka (1866: 199) referred to this species as differing from *E. vagina* in that 'lateral tubercles in this variety begin to grow at a much earlier stage, and the dorsal edge is somewhat narrower than in many Pondicherry specimens; further, the siphuncle often lies nearer to one edge than to the other; this, however, is not constant in all specimens'. The last statement is difficult to reconcile with a fastigate venter. Kossmat (1895: 157 (61), pl. 19(5) (figs 15, 16)) figured, as *Baculites vagina* var. *ootacodensis*, a specimen from Otacod, and one from Rautankupam (Pondicherry). The latter is a large *Eubaculites carinatus*. The former is distinctly binodose but is damaged and lacks the venter (Fig. 7F–H); we presume it to be a near-adult *E. labyrinthicus* but it could be a variant of *E. carinatus*. Most subsequent authors took Kossmat's figures to represent the species,

assuming it to have a tabulate venter. As indicated in the synonymy, most of these citations refer to *Eubaculites carinatus*.

Spengler (1923) described three baculitid species from Assam. The first, *Baculites vagina* (Spengler 1923: 54, pl. 4 (fig. 9)) from Tharia Ghat, is a typical representative of *E. labyrinthicus*. The second species from Assam (below Maomluh), described and figured by Spengler (1923: 54–55, pl. 4 (fig. 2a–b)) as *Baculites* sp. (cf. *vagina* Forbes var. *simplex* Kossmat), has perfectly smooth flanks, a compressed whorl section, and a narrowly rounded venter. This is similar to the lectotype of *Eubaculites simplex*, but for the shape of the venter. We are not sure if this is a *Eubaculites* at all; it may be a *Baculites* sensu stricto. The third species of Spengler (1923: 55, pl. 4 (fig. 8)) from Tharia Ghat, described and figured as *Baculites* cf. *B. anceps* Lamarck, has an inflated whorl section, but Spengler noted that 'The siphonal side is keel-shaped'. Again, we are not sure if it indeed is a *Eubaculites* at all—if it is, it might be a smooth variant of *E. vagina* or some other species.

Baculites rioturbioensis Hünicken, 1965 (p. 58, pl. 2 (figs 1–2), pl. 3 (figs 7–8), pl. 7 (fig. 1), pl. 8 (figs 6–8)) is from Santa Cruz Province, where Hünicken tentatively dated it as uppermost Campanian or basal Maastrichtian. *Baculites rioturbioensis* has a trigonal whorl section with a flattened dorsum and fastigate venter as in *E. labyrinthicus*. In some specimens of *B. rioturbioensis*, Hünicken (1965: 59) noted signs of depressions on either side of the siphuncle—possibly indications of an incipient ventral keel. Major differences between *B. rioturbioensis* and *E. labyrinthicus* are the lateral ornament. In *B. rioturbioensis* the flanks are ornamented by low, broad folds, in contrast to the generally well-defined, crescentic binodose flank ribs of *E. labyrinthicus*.

Baculites argentinicus Weaver (1927: 429, fig. 2) is probably a senior synonym of *B. rioturbioensis*, but is based on poorly preserved material and best regarded as a *nomen dubium*. Hünicken & Covacevich (1975: 146, pl. 2 (figs 1–3), text-fig. 5a–b) described, as *Baculites?* sp. B, a form with a fastigate venter and low ribs from Bahia Las Tablas, Quiriquina Island. This looks very much like *E. labyrinthicus*. It occurs at the same stratigraphic level (Nivel 12) as *E. carinatus* (= *B. lyelli*).

The lectotype of *Eubaculites vagina* var. *simplex* Kossmat (1895, pl. 19(5) (fig. 13)) (Fig. 7I–K), by subsequent designation of Kennedy (1986c: 195), has a fastigate venter like that of the lectotype of *E. labyrinthicus*, but lateral ornament is very faint, and the whorl section is not as inflated as that of typical *E. ootacodensis*. Kennedy (1986c: 194) regarded it as a synonym of *E. ootacodensis* (= *E. labyrinthicus* herein), but subsequent work on Australian faunas (Henderson *et al.* 1992) showed *E. simplex* to be a distinct, very compressed species (whorl breadth to height ratio 0.46–0.70) with a tear-shaped to pyriform whorl section, with or without a distinct keel, the venter being fastigate or narrowly tabulate. Smooth variants of *E. labyrinthicus* (e.g. Fig. 4), differ from *E. simplex* mainly in having a more inflated whorl section, but juvenile specimens are difficult to separate satisfactorily. The other specimen referred to *E. simplex* by Kossmat (1895, pl. 19(5) (fig. 14)) has an inflated whorl section, prominent lateral ribbing and indications of a tabulate keel; it is best referred to *E. carinatus*, as suggested by Kennedy (1986c: 196). *Eubaculites simplex* has a more compressed whorl section and smooth flanks.



Fig. 6. *Eubaculites labyrinthicus* (Morton, 1834). The original of Collignon's (1971, pl. 645 (fig. 2388)) *E. simplex* from locality 666, Antsoha (Belo sur Tsiribihina), Madagascar. This specimen shows prominent development of '*E. ootacodensis*' type of ribbed ornament on flanks in lieu of bituberculate as in typical *E. labyrinthicus*. $\times 1$.

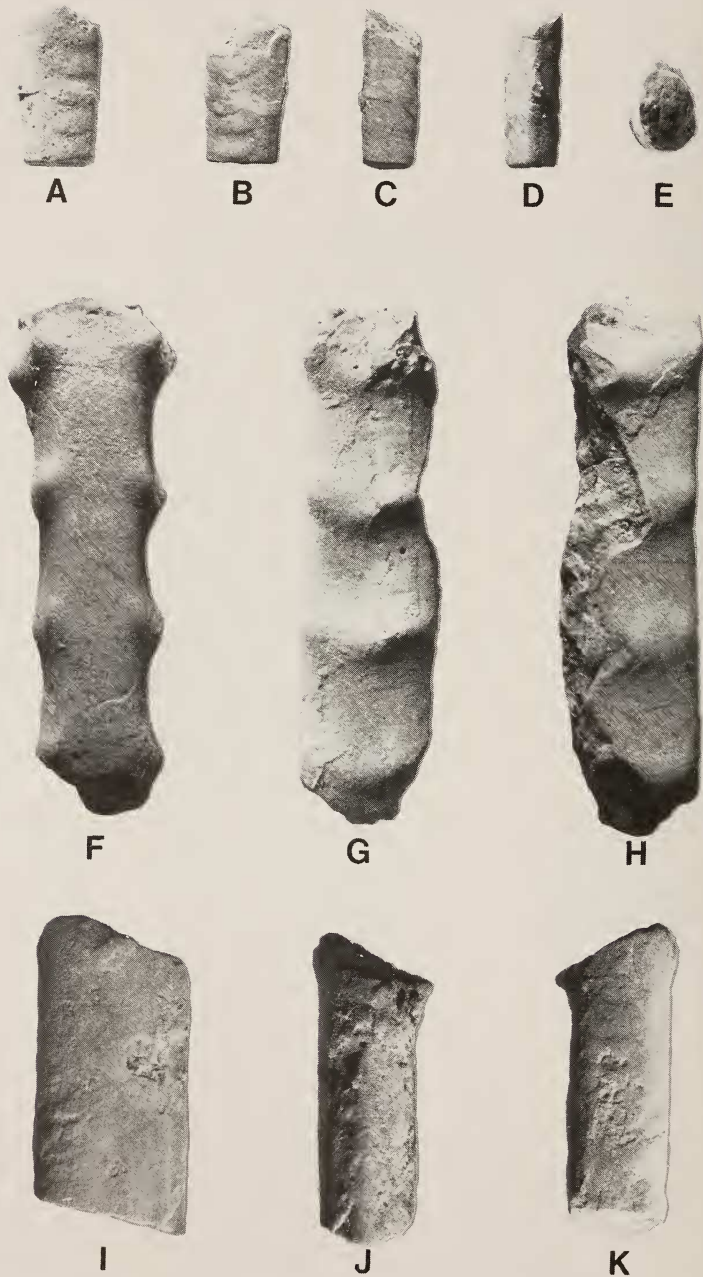


Fig. 7. A-E. *Eubaculites carinatus* (Morton, 1834). Paralectotype of *Eubaculites simplex* (Kossmat, 1895) the original of Kossmat, 1895, pl. 19 (5) (fig. 14) from Ootacod. GSI 14820. F-H. *Eubaculites labyrinthicus* (Morton, 1834). Cast of original of Kossmat, 1895, pl. 19 (5) (fig. 15) from Ootacod. GSI 14821. I-K. *Eubaculites simplex* (Kossmat, 1895). Cast of lectotype, the original of Kossmat, 1895, pl. 19(5) (fig. 13), from Arrialoor; GSI 14819. All specimens in the collections of the Geological Survey of India. All $\times 1$.

Occurrence

Maastrichtian, Prairie Bluff Chalk in Alabama, Navesink Formation in New Jersey, U. S. A. Maastrichtian near Ootacod, South India. Locality 20 of Kennedy & Klinger (1975: 283), Beds 3 (C) and 7 (G) of Klinger (1976, fig. 13), St Lucia Formation, Maastrichtian II, Zululand. Lower Maastrichtian, zone of *Pachydiscus gollevillensis* and *P. neubergicus* of Madagascar (as *Baculites simplex*).

Eubaculites vagina (Forbes, 1846)

Figs 8–20

- Baculites vagina* Forbes, 1846a: 144, pl. 10 (fig. 4a–c). D'Orbigny, 1850: 215. Stoliczka, 1866: 198 (pars), pl. 91 (figs 1–6), non pl. 90 (fig. 14) (= *E. labyrinthicus*); non pl. 90 (fig. 15) (= *E. carinatus*). Crick, 1898: 78, pl. 17 (fig. 5). Diener, 1925: 63 (pars).
- Baculites ornatus* d'Orbigny, 1847: pl. 3 (figs 3–6).
- Baculites vagina* Forbes. a) Typische Form Kossmat, 1895: 155 (50), pl. 19 (5) (fig. 17). non *Baculites vagina* Forbes. Forbes in Darwin, 1846b: 126, pl. 5 (fig. 3) (= *E. carinatus*). non *Baculites vagina* Forbes. Kossmat, 1895: pl. 19(5) (fig. 14) (= *E. carinatus*). non *Baculites vagina* var. *Cazadorana* Paulcke, 1907: 11, pl. 16 (fig. 5–5b). (= *Baculites* sp.). non *Baculites vagina* Forbes. Boule, Lemoine & Thévenin, 1907: 45(65), pl. 8(15) (fig. 3) (= *Baculites* sp.). non *Baculites* sp. cf. *vagina* Forbes. Woods, 1917: 36, pl. 20 (fig. 5a–d) (= ?*B. rectus*). non *Baculites vagina* Forbes. Spengler, 1923: 54, pl. 4 (fig. 9) (= *E. labyrinthicus*). non *Baculites* cf. *vagina* var. *otacodensis* Stoliczka. Crick, 1924: 140, pl. 9 (figs 4–5) (= ?*E. carinatus*). non *Baculites* cf. *vagina* var. *simplex* Kossmat. Crick, 1924: 140, pl. 9 (figs 6–7) (= ?*E. carinatus*). non *Baculites vagina* Forbes. Crick, 1924: 139, pl. 9 (figs 1–3) (= *E. carinatus*). non *Baculites vagina* Forbes. Spath, 1926: 80. non *Baculites vagina* Forbes. Wetzel, 1930: 90, pl. 10 (figs 3–4) (= *E. carinatus*). non *Baculites vagina* Forbes. Basse, 1931: 20, pl. 2 (figs 6–10) (= ?*Baculites* sp.). non *Baculites vagina* Forbes var. *Van Hoepeni* Venzo, 1936: 116(58), pl. 10(6) (figs 11–12) (= *Baculites vanhoepeni*). non *Eubaculites vagina* (Forbes). Spath, 1940: 49, text-fig. 1a (= *E. carinatus*). non *Eubaculites vagina* (Forbes): Brunnschweiler, 1966: 29, pl. 1 (fig. 7), pl. 2 (figs 1–14), text-figs 12–14 (= *E. carinatus*).
- Eubaculites vagina* (Forbes): Collignon, 1971: 15, pl. 645 (fig. 2391), p. 18, pl. 646 (fig. 2394). Klinger, 1976: 87, pl. 35 (figs 1–4), pl. 36 (figs 1–4), pl. 37 (figs 1–5), pl. 38 (figs 1–3, ?fig. 4), pl. 39 (fig. 2), pl. 42 (fig. 1, ?fig. 4), pl. 43 (figs 5–12). Kennedy, 1977, text-fig. 31 (1–2). Klinger & Kennedy, 1980: 299, fig. 5a–c. Kennedy 1986c: 194. Kennedy & Henderson, 1992: 712, pl. 5 (figs 10–13), pl. 7 (figs 1–18), pl. 8 (figs 1–12), pl. 9 (figs 1–13), pl. 10 (figs 1–3), text-fig. 1C, F.
- Eubaculites* Kennedy, 1989, fig. 17i–j.

Type

The lectotype of *E. vagina* is the original of Forbes (1846a, pl. 10 (fig. 4)) from the Valudavur Beds of Southern India, BMNH C49762 (herein Fig. 8), designated by Kennedy & Henderson (1992: 713). Klinger (1976: 88) referred to it as 'holotype'—this is not considered a valid lectotype designation.

Diagnosis

Eubaculites with tabulate siphonal keel and bituberculate lateral ornament; some rare variants may be smooth.



Fig. 8. *Eubaculites vagina* (Forbes, 1846). A-C. BMNH C49762, the lectotype, the original of Forbes (1846, pl. 10 (fig. 4)); Geological Society Collection R10488. From the Valudavur Formation of southern India. $\times 1$.

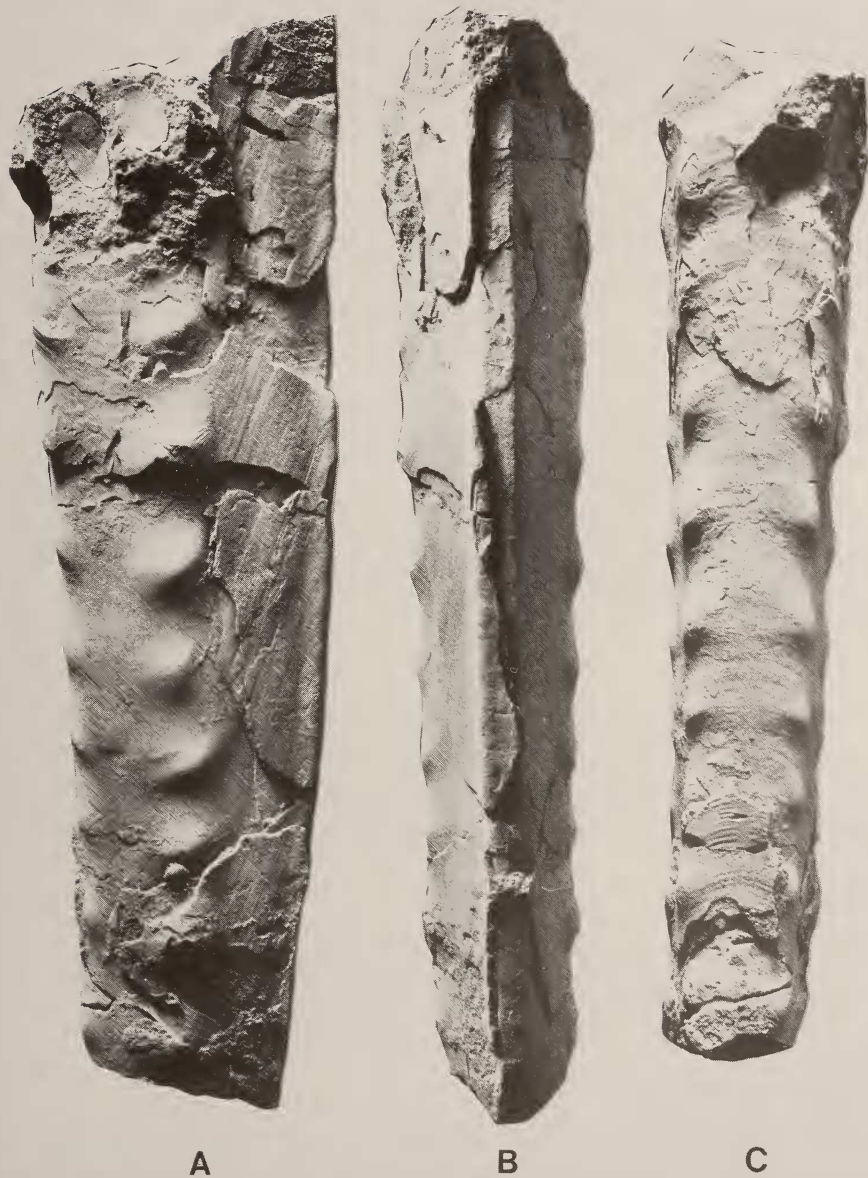


Fig. 9. *Eubaculites vagina* (Forbes, 1846). A–C. BMNH C77593. Adult specimen with typical bituberculate lateral ornament. From the Valudavur Formation of southern India. $\times 1$.

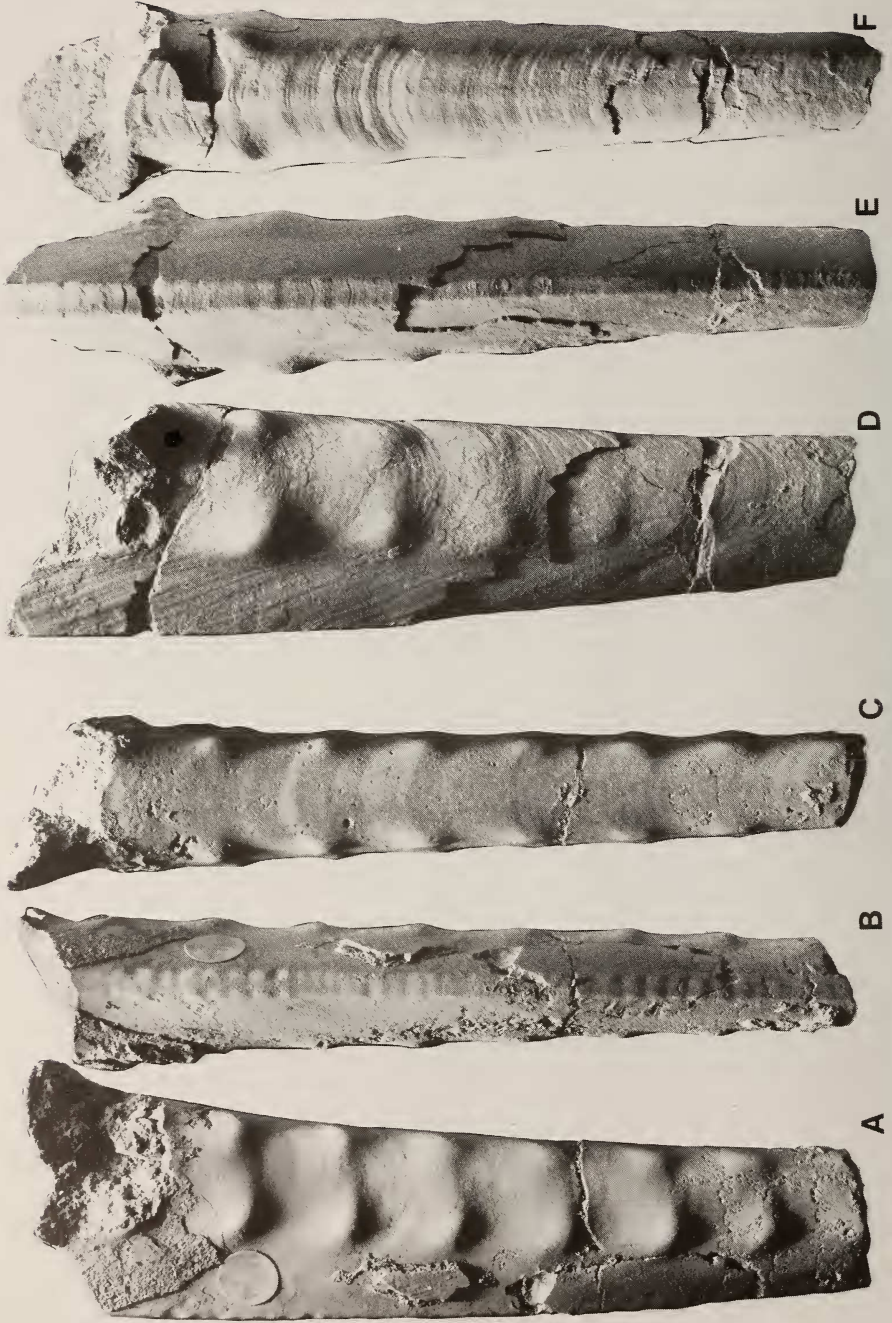


Fig. 10. *Eubaculites vagina* (Forbes, 1846). A-C. BMNH C51143. D-F. BMNH C51141. Two specimens showing typical bituberculate lateral ornament. Both specimens are from the Valudavur Formation of southern India. $\times 1$.

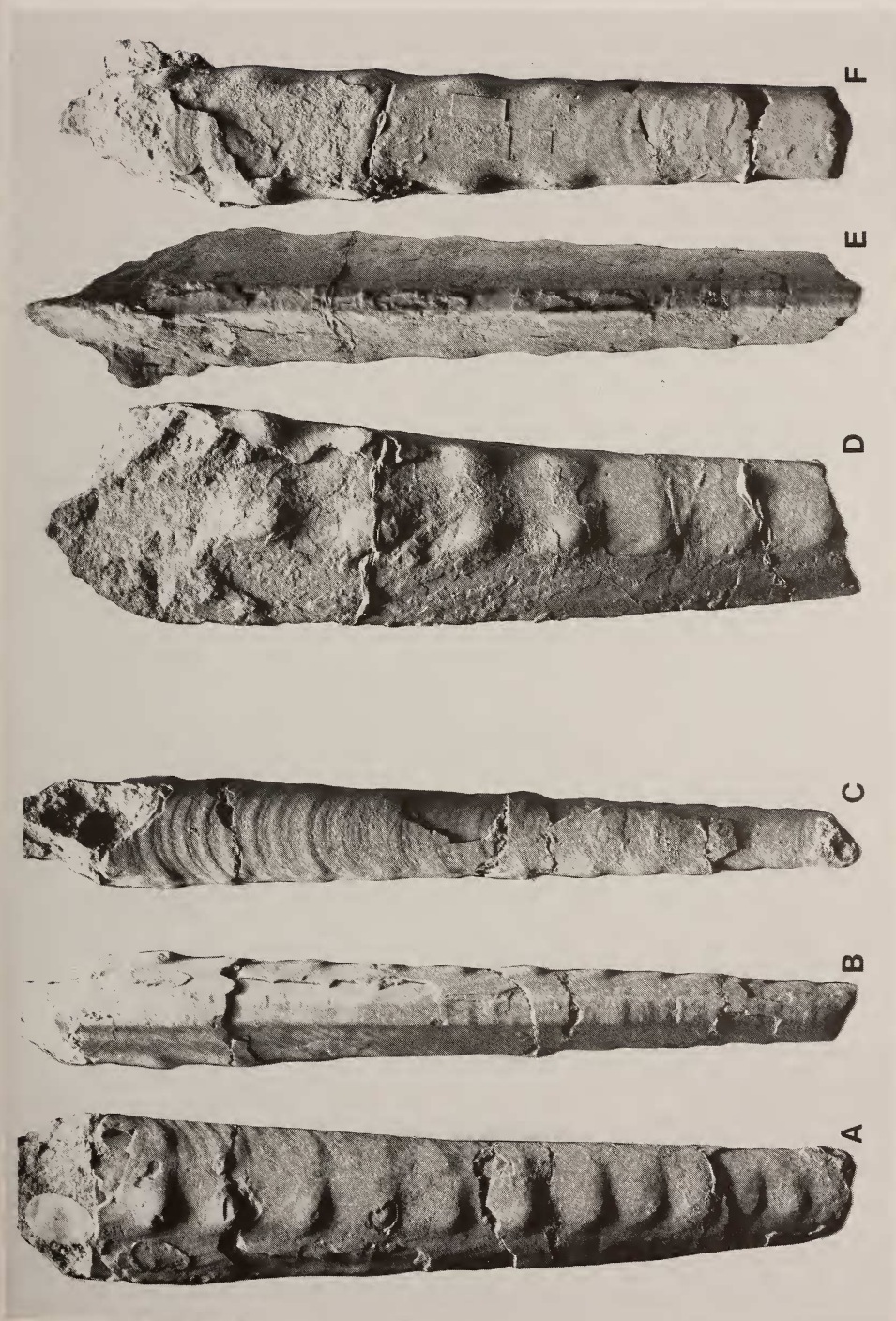


Fig. 11. *Eubaculites vagina* (Forbes, 1846). A-C. BMNH C77594. D-F. BMNH C2583, specimens showing typical bituberculate lateral ornament. Both specimens are from the Valudavur Formation of southern India. $\times 1$.

Description

Full descriptions of the species are given by Klinger (1976) and Kennedy & Henderson (1992) and need not be repeated. As yet, no adult specimens of *E. vagina* have been found in Zululand, and, in retrospect, we suspect that the juvenile specimens referred to this species by Klinger (1976, pl. 42 (fig. 4)) (herein Fig. 52A–C) are better referred to *E. labyrinthicus*.

Discussion

One of us (Klinger 1976) previously described and figured syn- and topotype material from South India, and described the variation shown by this species. Due to unforeseen circumstances, the original figures were reduced so as to be practically unrecognizable. These specimens are here refigured (Figs 8–15).

Eubaculites vagina is unique in the genus *Eubaculites*, in having two rows of lateral tubercles combined with a tabulate ventral keel. Specimens with distinct bituberculate ornament, here regarded as being typical of *E. vagina*, include BMNH C77593 (Fig. 9), C51141 (Fig. 10D–F) and C51143 (Fig. 10A–C), C77594 (11A–C), and C2583 (Fig. 11D–F). Some specimens are nearly smooth, with no lateral ornament, e.g. C51142 (Fig. 15A–C), C51145 (Fig. 15I–J)) and the specimen figured by Stoliczka (1866, pl. 91 (figs 1–2)) (herein Fig. 16). We are not quite sure if these are, in fact, smooth *E. vagina*, or *Eubaculites latecarinatus*; we think *E. vagina*, as they occur with typical representatives of that species. Also, typical populations of *E. latecarinatus* are, as yet, unknown from South India. BMNH C51140 (Fig. 13) and the specimen figured by Stoliczka (1866, pl. 91 (fig. 4)) (herein Fig. 19) differ from other specimens of *E. vagina* in their denser and more oblique, though weaker lateral tuberculation. This may possibly be a feature of the adult body chamber. The differences in size between these specimens and the lectotype, which also appears to be adult, may be an indication of dimorphism. However, the largest known specimens of *E. vagina* are all significantly smaller than the largest *E. carinatus* and *E. latecarinatus*. We are not sure if this is a consistent feature or only due to the relatively small number of adult *E. vagina* known.

Until now, unequivocal adult bituberculate shells of *E. vagina* have only been found in South India and in Madagascar—the doubtful Zululand specimens reported by Klinger (e.g. 1976, pl. 42 (fig. 4)) are juveniles and better referred to *E. labyrinthicus*. Collignon (1971: 15, pl. 645 (fig. 2391), p. 18, pl. 646 (fig. 2394)) (herein Fig. 20) recorded *E. vagina* from the 'Lower' Maastrichtian of Madagascar, Zone à *Pachydiscus gollevillensis* et *P. neubergicus*. This is true *E. vagina*, unlike the totally incorrect interpretation of the species by Boule *et al.* (1907: 65, pl. 8(15) (fig. 3)) and Basse (1931: 20) (*vide* Spath 1953: 46). These Madagascan specimens appear to be true *Baculites*. The Australian specimens referred to *E. vagina* by Brunnschweiler (1966: 29, pl. 1 (fig. 7), pl. 2 (figs 1–14), text-figs 12–14) are all typical representatives of *E. carinatus*.

The specimen figured by D'Orbigny (1847, pl. 3 (fig. 3)) as *Baculites ornatus* is a composite synthetograph. Nevertheless, it clearly shows typical *E. vagina* bituberculate lateral ornament. Stoliczka (1866: 199) commented that '*B. ornatus* . . . probably is from Pondicherry itself'. The fact that the vast collections from the Quiriquina Formation of Stinnesbeck (1986: 207) yielded only *E. lyelli* but no *E. vagina (ornatus)* confirms Stoliczka's suspicions. Hünicken & Covacevich (1975: 159–160) discussed the

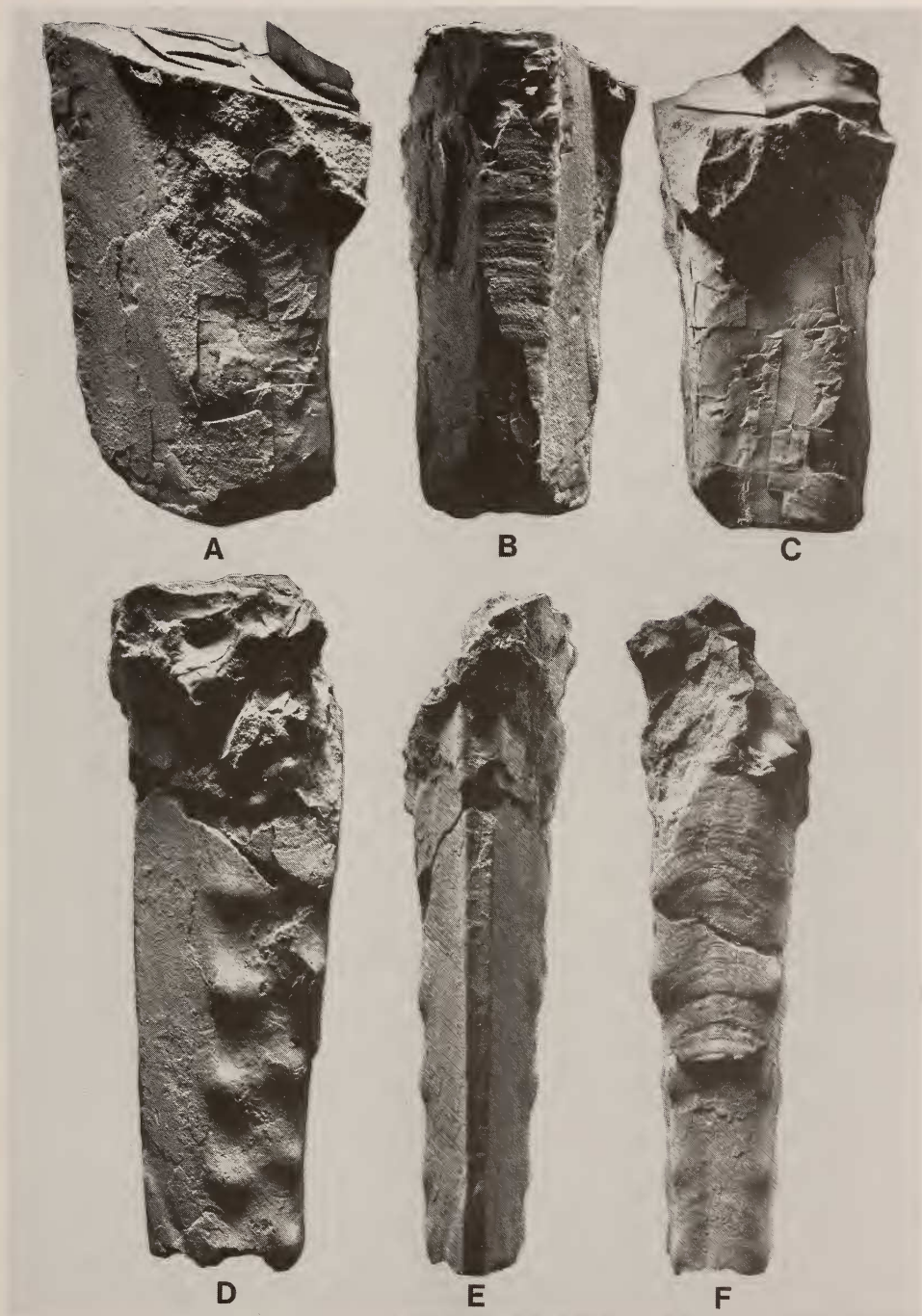


Fig. 12. *Eubaculites vagina* (Forbes, 1846). A-C. BMNH C51146. Body chamber fragment with part of the aperture preserved. D-F. BMNH C51147. Specimen with prominent bituberculate ornament. Both specimens from the Valudavur Formation of southern India. Both $\times 1$.

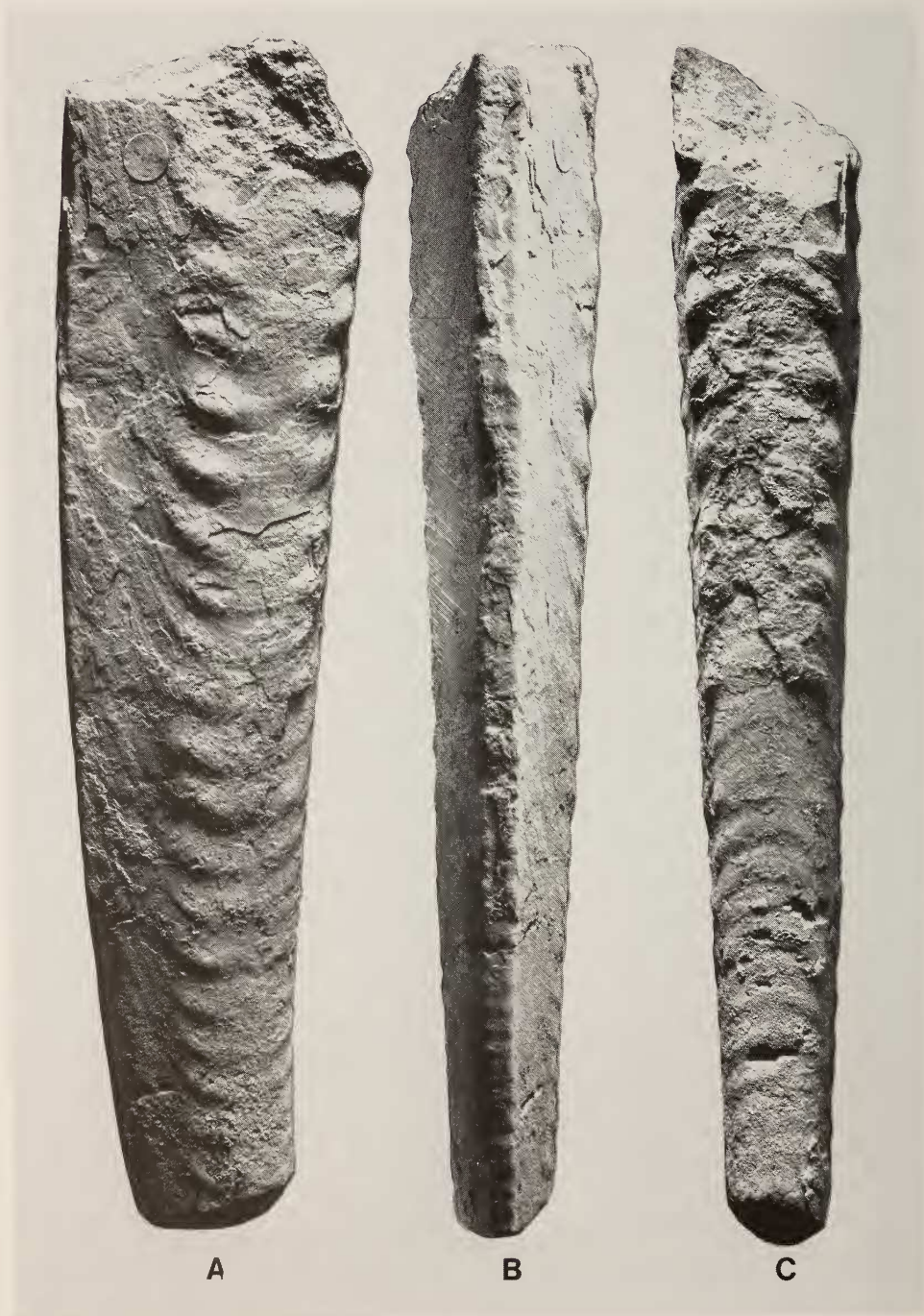


Fig. 13. *Eubaculites vagina* (Forbes, 1846). A-C. BMNH C51140, part of body chamber, from the Valudavur Formation of Pondicherry, southern India. $\times 0,75$.



Fig. 14. *Eubaculites vagina* (Forbes, 1846). A-C. BMNH C51149. D-F. BMNH C51144. G-I. BMNH C73569. J-L. BMNH C51145. M-O. BMNH C73569. A series of specimens illustrating range of ontogenetic and intraspecific variation. All specimens are from the Valudavur Formation of southern India. All $\times 1$.

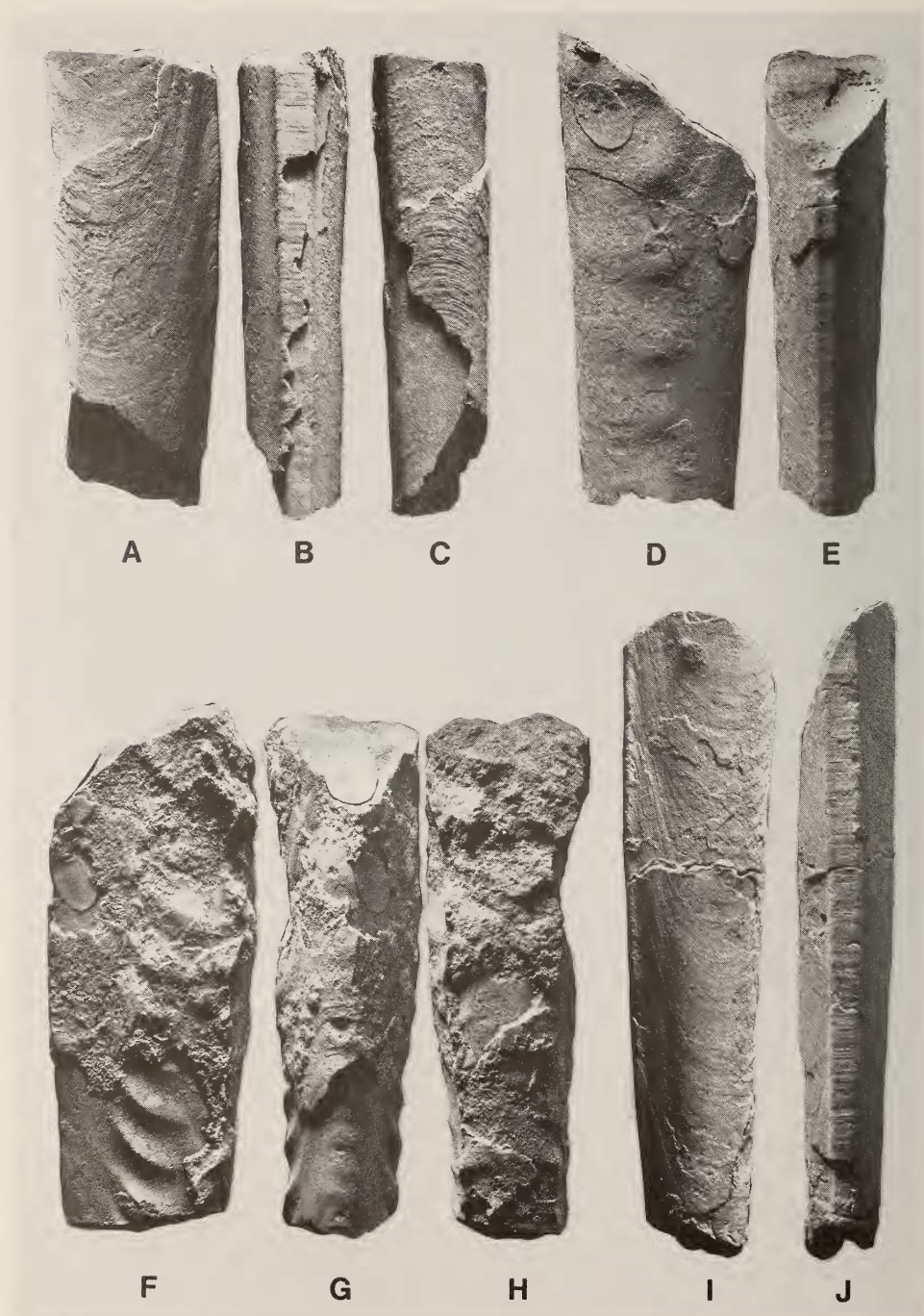


Fig. 15. *Eubaculites vagina* (Forbes, 1846). A–C. BMNH C51142, a smooth form of *E. vagina* showing fine striae on shell and smooth surface on internal mould. D–E. BMNH C51150. F–H. BMNH C77599, a body chamber fragment with crowded ornamentation. I–J. BMNH C51145, another smooth form. All specimens are from the Valudavur Formation of southern India. All $\times 1$.

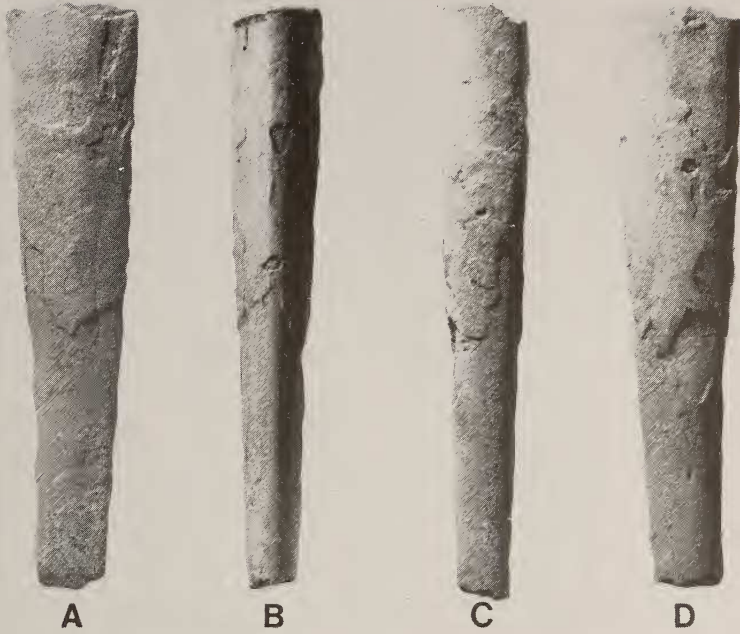


Fig. 16. *Eubaculites vagina* (Forbes, 1846). A smooth, non-ornate variety of the species. Cast of the original of Stoliczka, 1866, pl. 91 (fig. 2), from Pondicherry. Collection of the Geological Survey of India, GSI 408. $\times 1$.

systematic position of *B. ornatus*, stating that the type of *B. ornatus* could not be found in the D'Orbigny collections, but concluded that (1975: 160) it was a synonym of *E. vagina*.

Eubaculites vagina has been reported from the Ukrainian SSR (see Kennedy 1986a: 1015; 1986c: 194) on the basis of a crushed baculitid from the Maastrichtian flysch described and figured by Wisniowski (1907: 199, pl. 17 (fig. 9)) as *Baculites anceps*. Admittedly, the specimen does show bituberculate lateral ornament, but this is due to a longitudinal fracture and subsequent displacement of ribbing ('... dargestellten Gehäuse, welches leider in der Längsrichtung zerbrochen ist und infolgedessen eine kleine Verschiebung beider Teile erlitt'—Wisniowski 1907: 199).

Baculites labyrinthicus Morton (1834: 44, pl. 13 (fig. 10); see above) also has bituberculate flank ornament but a fastigiate rather than tabulate venter. *Baculites binodosus* Noetling, 1897 (p. 77, pl. 23 (fig. 3)) (herein Fig. 56) is based on a single fragment; it has a single feeble row of dorsolateral tubercles and a feebly tabulate venter. It may represent a further distinct species of *Eubaculites*, probably close to *E. simplex*.

Occurrence

Maastrichtian of South India and Madagascar; only dubious juveniles, best referred to *E. labyrinthicus*, are known in Zululand.

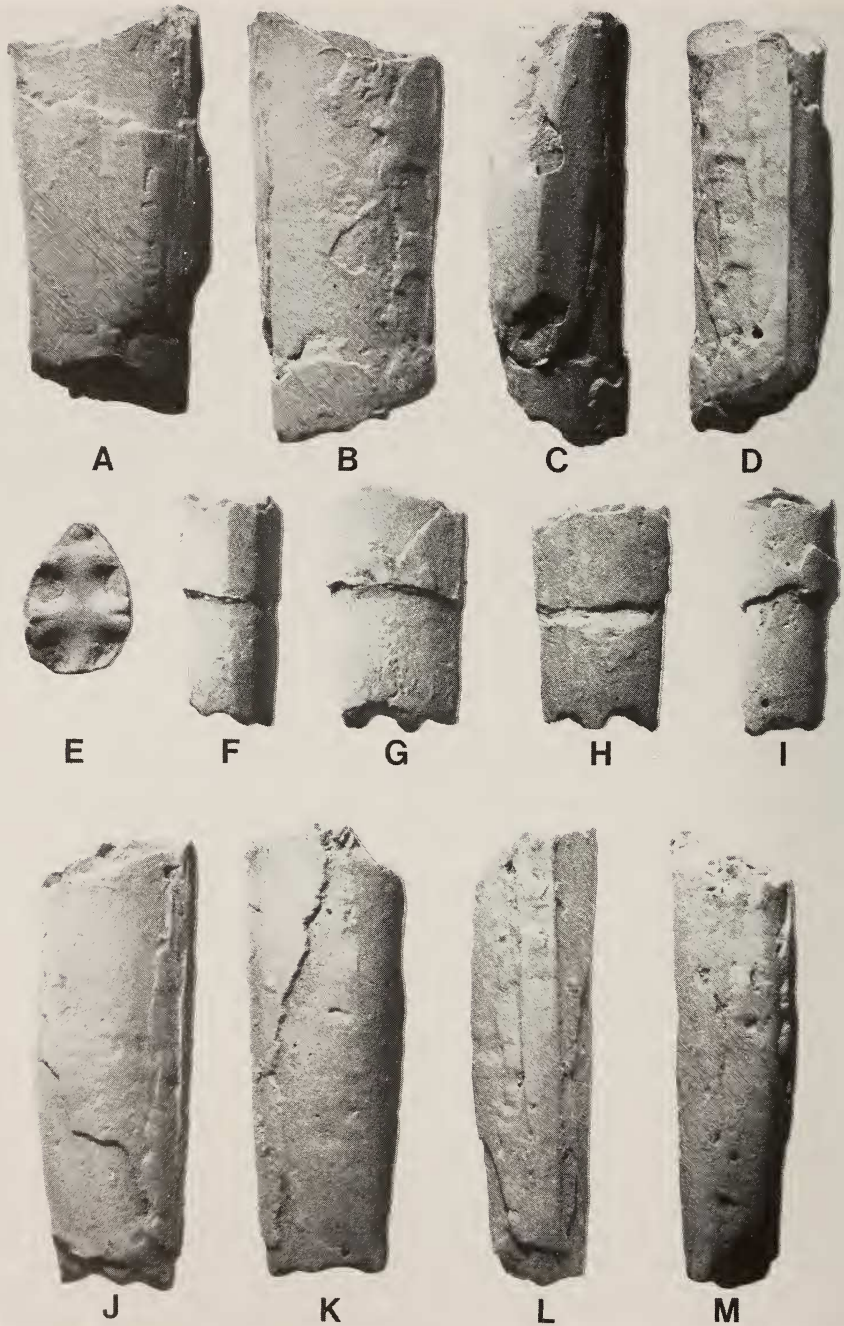


Fig. 17. *Eubaculites vagina* (Forbes, 1846). A-D. Cast of original of Stoliczka, 1866, pl. 91 (fig. 1), part, GSI 408. E-I. Cast of original of Stoliczka, 1866, pl. 91 (fig. 3). GSI 410. J-M. Cast of original of Stoliczka, 1866, pl. 91 (fig. 1), part, GSI 408. All from Pondicherry, Collection of the Geological Survey of India. $\times 1$.



Fig. 18. *Eubaculites vagina* (Forbes, 1846). A-C. Cast of original of Stoliczka, 1866, pl. 91 (fig. 5) from Pondicherry; GSI 412. D. Cast of original of Stoliczka, 1866, pl. 91 (fig. 4) from Pondicherry; GSI 411. Both in the collections of the Geological Survey of India. $\times 1$.



Fig. 19. *Eubaculites vagina* (Forbes, 1846). Cast of original of Stoliczka, 1866, pl. 91 (fig. 4) from Pondicherry. Collections of the Geological Survey of India, GSI 411. $\times 1$.

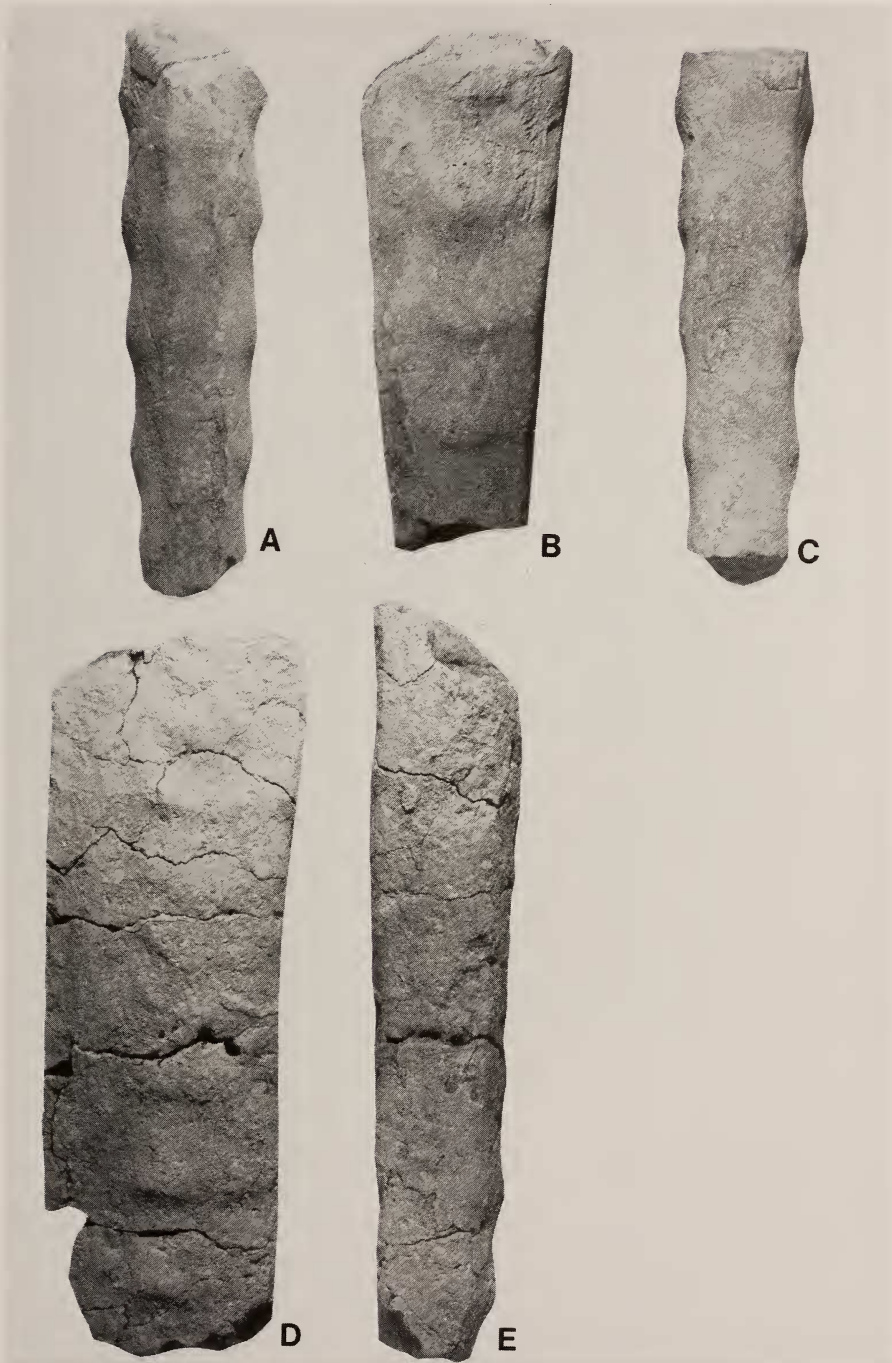


Fig. 20. *Eubaculites vagina* (Forbes, 1846). A–C. The original of Collignon (1971, pl. 645 (fig. 2391)) from locality 504, Mont Ambinda-Mikoboka (Manera), Madagascar. D–E. The original of Collignon (1971, pl. 646 (fig. 2394)) from locality 671, Antsoha (Bela Sur Tsiribihina), Madagascar. All $\times 1$.

Eubaculites carinatus (Morton, 1834)

Figs 7A–E, 21–30, 31A–G, 32–35, 36E–F, 37–38, 42A, 52G–H

- Baculites carinatus* Morton, 1834: 44, pl. 13 (fig. 1). Stephenson, 1955: 134, pl. 24 (figs 5–9).
Baculites vagina Forbes: Darwin, 1846: 126. Forbes *in* Darwin, 1846*b*: pl. 5 (fig. 3). Steinmann, 1895: 89, pl. 6 (fig. 4), text-figs 8–10. Kossmat, 1897*b*, pl. 6 (fig. 4). Wilckens, 1904: 188. Diener, 1925: 63 (pars). Wetzel, 1930: 90, pl. 10 (figs 3–4). Hoffstetter *et al.*, 1957: 300, 302.
Baculites Lyelli d'Orbigny, 1847, pl. 1 (figs 3–7); 1850: 215. Olsson, 1944: 104, pl. 16 (figs 3–5), text-fig. 1.
Baculites tippaensis Conrad, 1858: 334, pl. 35 (fig. 27).
Baculites spillmani Conrad, 1858: 335, pl. 35 (fig. 24).
Baculites anceps Lamarck. Binckhorst, 1861: 42, pl. 5d (fig. 3a–d).
Baculites chicoensis Gabb, 1864: 80 (pars), pl. 14 (fig. 29, 29a); *non* pl. 17 (fig. 27, 27a), *non* pl. 14 (fig. 27b).
Baculites vagina var. *Otacodensis* Stol.: Kossmat, 1895: 157(61) (pars), pl. 19(5) (fig. 16), (?*non* fig. 15 = ?*E. labyrinthicus*).
Baculites vagina var. *simplex* Kossmat, 1895: 156(60) (pars), pl. 19(5) (fig. 14 only).
non Baculites vagina var. *nov. cazadorianus* Paulcke, 1907: 11, pl. 16 (fig. 5–5b) (= *Baculites* sp.).
non Baculites vagina var. *cazadoriana* Paulcke: Diener, 1925: 63.
Baculites sheringomensis Crick, 1924: 139, pl. 9 (figs 1–3).
Baculites cf. *vagina* var. *otacodensis* Stoliczka: Crick, 1924: 140, pl. 9 (figs 4–5).
Baculites cf. *vagina* var. *simplex* Kossmat: Crick, 1924: 140, pl. 9 (figs 6–7).
Eubaculites otacodensis Stoliczka. Spath, 1940: 49, pl. 1 (fig. 3), text-fig. 1b. Wright, 1957: L218, figs 245, 246a–c. Collignon, 1971: 18, pl. 646 (fig. 2395).
? *Baculites anceps* (Lamarck) d'Orbigny: Haas, 1943: 13 (figs 16–17 only).
Eubaculites lyelli (d'Orbigny): Matsumoto & Obata, 1963: 97. Hünicken & Covacevich, 1975: 149, pl. 1 (figs 5–12), pl. 2 (figs 4–9), pl. 3 (figs 1–8), pl. 4 (figs 1–8), pl. 5 (figs 1–4), text-figs 6–28. Stinesbeck, 1986: 207, pl. 9 (figs 6–8), text-fig. 24D, d. Kennedy & Summesberger, 1986: 197, pl. 14 (figs 1–5, 9–14). Kennedy, 1986*a*: 1016, pl. 1 (figs 1–3), pl. 2 (figs 3–8), pl. 3 (figs 2–8, 13–21). Kennedy, 1986*b*, fig. 10c, d. Kennedy, 1986*c*: 195, pl. 27 (figs 5–8), pl. 32 (figs 13–14). Immel, 1987: 129.
Eubaculites argentinius (Weaver): Leanza, 1964: 95, pl. 1 (figs 1–5), text-fig. 1.
Eubaculites sp. Garcia & Camacho, 1965: 72, pl. 1 (fig. 4).
Eubaculites vagina (Forbes): Brunnschweiler, 1966: 29, pl. 1 (fig. 7), pl. 2 (figs 1–14), text-figs 12–14.
Eubaculites ootacodensis (Stoliczka): Brunnschweiler, 1966: 27, pl. 1 (figs 9–14), text-figs 9–11. Matsumoto, 1959: 166, pl. 43 (fig. 6), pl. 44 (figs 1–3), text-figs 84a–b, 85a–b. Riccardi, 1974: 388, pl. 1 (figs 1–7), pl. 2 (figs 1–4, 6), pl. 3 (figs 1–6), pl. 4 (figs 1–7), text-fig. 2; 1980: 11–14, figs 1–2. Klinger, 1976: 90 (pars), pl. 39 (fig. 1, *non* fig. 3), pl. 41 (figs 1–2), pl. 42 (figs 3, 8), *non* pl. 43 (fig. 1), text-fig. 11c.
Eubaculites kossmati Brunnschweiler, 1966: 31, pl. 2 (figs 15–17), pl. 3 (figs 1–7), text-fig. 15.
Eubaculites multicostatus Brunnschweiler, 1966: 32, pl. 3 (figs 8–12), text-fig. 16.
Eubaculites carinatus (Morton, 1834): Henderson *et al.*, 1992: 150, figs 6F–G, 14–16, 17A–C, G–J, 18–20. Kennedy & Henderson, 1992: 716, text-fig. 5A–C.

Type

Holotype, by monotypy, is ANSP 72866 in the collections of the Academy of Natural Sciences, Philadelphia, the original of Morton (1834, pl. 13 (fig. 1)), from the Prairie Bluff Chalk of Alabama (Fig. 21). The lectotype of *Baculites lyelli* d'Orbigny, 1847, by subsequent designation by Kennedy (1986*a*: 1016) is MNHP R1020a (refigured by Kennedy 1986*a*, pl. 1 (figs 1–3)) (herein Fig. 22F–G); paralectotypes are MNHP R1020b–c (formerly D'Orbigny collection no. 7206) (herein Fig. 22D–E). These specimens are presumably the basis of D'Orbigny's highly idealized figures (1847, pl. 1 (figs 3–7)). The locality is given as 'Conception', but it is more likely Quiriquina Island, as also later stated by D'Orbigny's (1850: 715) Prodrôme entry.

Material

We have numerous specimens, including SAS H54/11 from locality 132, degraded cliff and foreshore platform 300 m north-north-east of the northern jetty at Charter's Creek Rest Camp, St Lucia Formation, Maastrichtian I; SAM-PCZ7070, PCZ7073, PCZ7427, PCZ7442, PCZ7429, PCZ7788, PCZ8317-8330, SAS H54/11, SAS Z2204 from locality 134, cliffs and foreshore section 1,2 km south of Charter's Creek Rest Camp, St Lucia Formation, Maastrichtian I; SAM-PCZ7047, PCZ8651, SAS H63/12, H63/1, H61/20, OUM KX1835-1838, SAS Z2204 from an unspecified horizon at locality 133; H60F/2, SAS H60F/14, H60H/17, Bed F; SAS H60H/17, Bed H, locality 133, cliff section and beach platform below Charter's Creek Rest Camp, St Lucia Formation, Maastrichtian I; PCZ8831 from locality 125, foreshore platform north of Fannies Island, eastern shores of the southern peninsula, Maastrichtian a (ex Campanian IV); SAM-PCZ8647, PCZ8650, SAS H48/1, SAS L97a-b from locality 131, low cliffs and foreshore sections 3, 1 km north of Charter's Creek Rest Camp, St Lucia Formation, Maastrichtian II; SAM-PCZ8311, PCZ8648, loose at locality 20; SAS H163C/4, Bed 3 (C); H163D/1, OUM KX1834, Bed 4 (D); SAS H20/5, H163E/5, Bed 5 (E); SAS H163G, OUM KX1825, KX1827, KX1839-1840, Bed 7(G) at locality 20, section at junction of old course of the Mfolozi River, the present course and the unnamed stream draining south from Lake Mfuthululu, St Lucia Formation, Maastrichtian I-II.

Dimensions

<i>Specimen</i>	<i>Wb</i>	<i>Wh</i>	<i>Wb/Wh</i>	<i>Tapering</i>
SAS Z2204a	8	14	0,57	—
SAS H163D/1	10	16	0,62	—
	11	20	0,55	11,4 (D = 35)
SAM-PCZ7442	10	19	0,53	—
SAM-PCZ8320	9	17	0,53	—
	12	20	0,60	7,3 (D = 55)
SAM-PCZ8322	12	19	0,63	—
	10	14	0,71	12,5 (D = 40)
SAM-PCZ8323	11	17	0,65	—
	10	14	0,71	8,8 (D = 34)
SAM-PCZ8328	10	16	0,62	—
	9	13	0,69	—
	7	10	0,70	12,0 (D = 25)
SAM-PCZ8330	9	13	0,69	—
SAM-PCZ8319	11	16	0,69	—
	9	13	0,69	10 (D = 30)
SAM-PCZ8326	9	13	0,69	—
	7	10	0,70	13,0 (D = 23)
SAM-PCZ8329	9	13	0,69	—
	8	11	0,72	11,8 (D = 17)
SAM-PCZ8327	9	13	0,69	—
	7	9,5	0,74	13,5 (D = 26)

SAM-PCZ8321	9	14	0,64	—
SAS H63/1	21	42	0,50	—
	24	47	0,51	4,9 (D = 102)
SAM-PCZ7047	24	43	0,59	—
	19	34	0,56	10,6 (D = 85)
SAM-PCZ7427	20	34	0,56	—
	14	25	0,56	8,1 (D = 94)
SAS 97	—	44	—	—
	—	34	—	9,0 (D = 111)
SAS H60H/17	8	31	0,58	—

Diagnosis

Eubaculites with tabulate siphonal keel and lateral ornament consisting of ribbing only.

Description

The holotype of *Eubaculites carinatus* (Fig. 21) is a phosphatic internal mould of a body chamber and parts of two camerae, 47,5 mm long, with a whorl breadth to height ratio of 0,74. The whorl section is pyriform, with a flattened dorsum, narrowly rounded dorsolateral margin and broadly rounded flanks, with greatest breadth below mid-flank. The outer flanks are convergent, and separated by a narrow longitudinal groove from narrowly rounded ventrolateral shoulders; the venter is narrow and bears a tabulate keel. The rib index is 2,5. The ribs are broad, strong and concave, as wide as the interspaces, extending from the dorsolateral margin to the middle third of the flank. On the ventral third of the flank the ribs weaken, break down into riblets and striae and project strongly forwards to the ventrolateral margin, where they flex back and are feebly convex. They strengthen markedly at the ventrolateral shoulder and are coarse and distant on the venter, which is markedly serrate in profile; ventral ribs are approximately twice as numerous as those on the flank.

Typical Zululand representatives of this species are easily identified by the pyriform whorl section, tabulate venter and the crescentic flank ribs. There is, however, considerable variation in the strength of the flank ribs, rib index, and whorl breadth to height ratio.

The shell may grow to a great size (e.g. Figs 25, 26C, 36F)—the maximum whorl height measured is 80 mm. At the smallest diameter available (PCZ8318) (Fig. 28B), the whorl section is tear-shaped, with a narrow, rounded venter. Flattening of the keel only takes place at whorl heights varying between 15 mm and 20 mm; development of the typical tabulate keel takes place even later. Tapering is rapid in small specimens; large specimens have essentially parallel ventral and dorsal sides and a very slow rate of taper as can be seen in the list of dimensions.

Flank ornament typically consists of crescentic ribs, arising, and protruding above the dorsal edge, most prominent at mid-flank, and, in adult specimens, disappearing near the ventrolateral furrows demarcating the keel. The stage of appearance, strength and density of ribbing is extremely variable as can be seen from the figured specimens. Prominent flank ornament is best shown in PCZ7047 (Fig. 24A–C), whereas PCZ8651 (ex H63/1) (Fig. 27) merely shows lateral undulations, and is morphologically transitional to *E. simplex*.

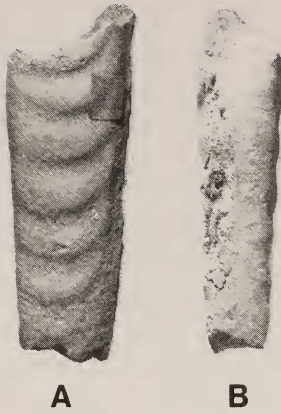


Fig. 21. *Eubaculites carinatus* (Morton, 1834). The holotype, ANSP 72866, from the Prairie Bluff Chalk of Alabama. $\times 1$.

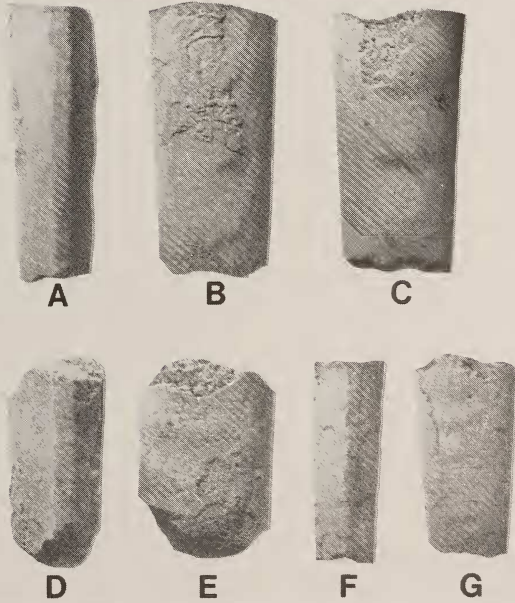


Fig. 22. *Eubaculites carinatus* (Morton, 1834). A-C. Unnumbered specimen, presumably from India. D-E. Paralectotype of *Baculites lyelli* d'Orbigny, 1847, from Quiriquina Island, Chile; MNHP R1020b-c. F-G. Lectotype of *Baculites lyelli* d'Orbigny, 1847, from Quiriquina Island, Chile; MNHP R1020a. All specimens housed in the collections of the Muséum National d'Histoire Naturelle, Paris. $\times 1$.

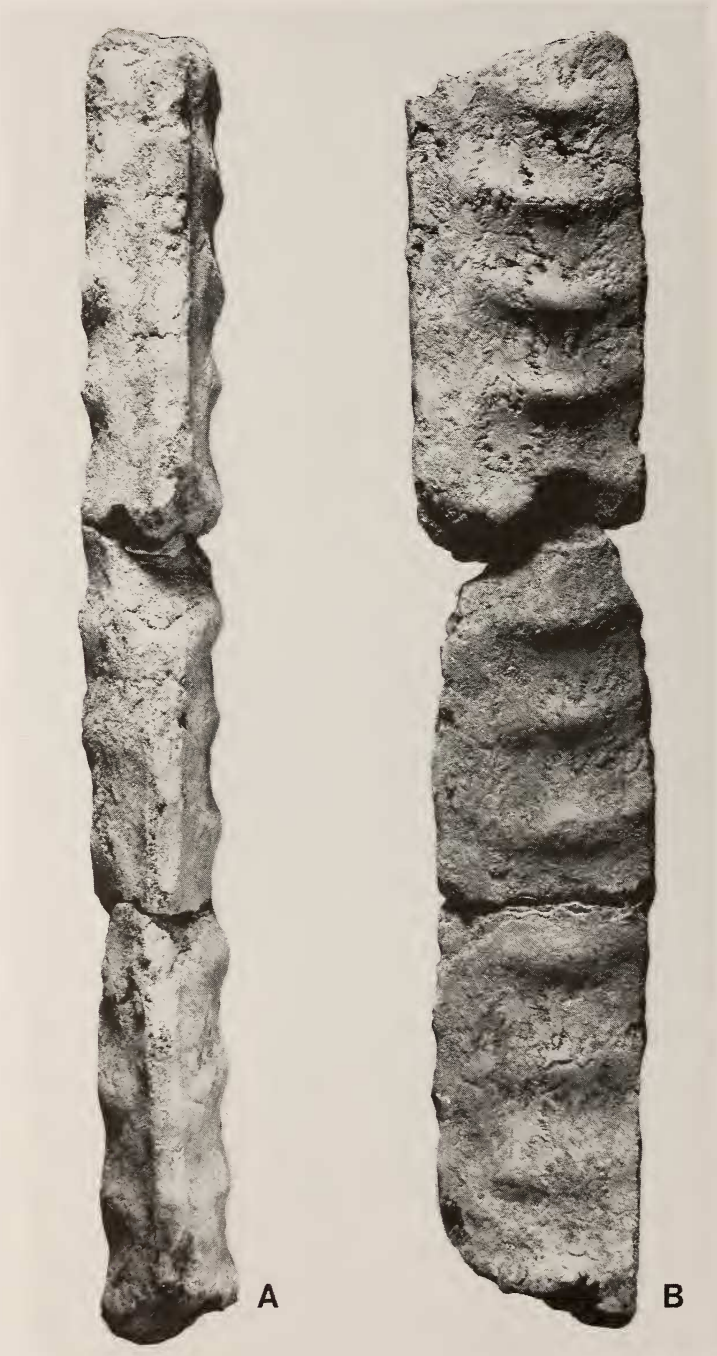


Fig. 23. *Eubaculites carinatus* (Morton, 1834). SAM-PCZ8647 from locality 131, Zululand, St Lucia Fm, Maastrichtian II. $\times 0,75$.

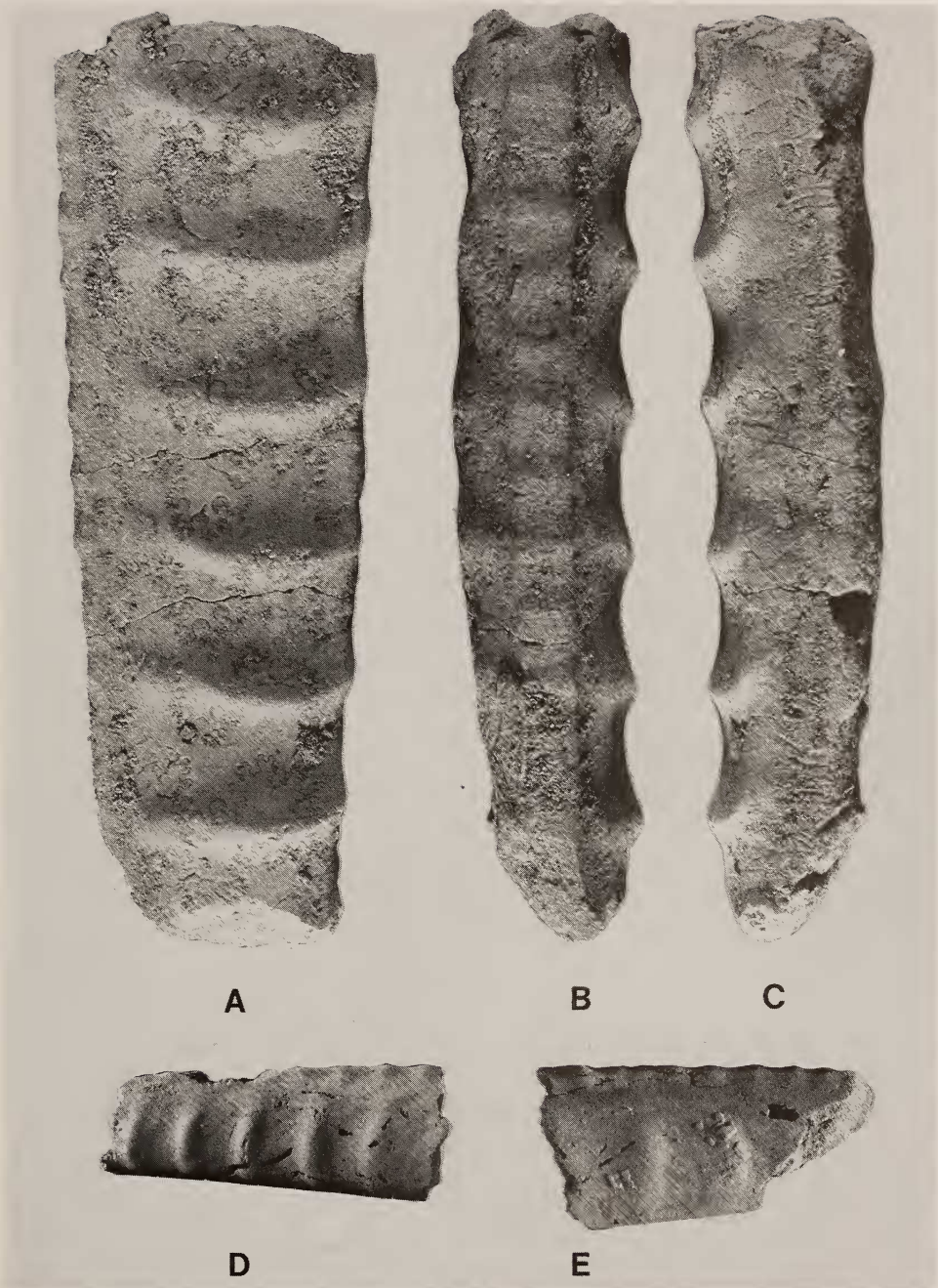


Fig. 24. *Eubaculites carinatus* (Morton, 1834). A-C. SAM-PCZ7047 from locality 133, Zululand, St Lucia Fm, Maastrichtian I. D. SAM-PCZ8322. E. SAM-PCZ8648. Both loose from the top of the section at locality 20, Zululand, St Lucia Fm, Maastrichtian II.



Fig. 25. *Eubaculites carinatus* (Morton, 1834). A. SAM-PCZ8649 from locality 134, Zululand, St Lucia Fm, Maastrichtian I.
B. SAM-PCZ8331 from locality 125, Zululand, St Lucia Fm, Maastrichtian a. Both $\times 1$.



Fig. 26. *Eubaculites carinatus* (Morton, 1834). A. SAM-PCZ7427, specimen with very weak lateral ornament, transitional to *E. latecarinatus*, from locality 134, Zululand, St Lucia Fm, Maastrichtian I. B. SAM-PCZ7073 from locality 134. C. SAM-PCZ8650 from locality 131, Zululand, St Lucia Fm, Maastrichtian II. All $\times 1$.

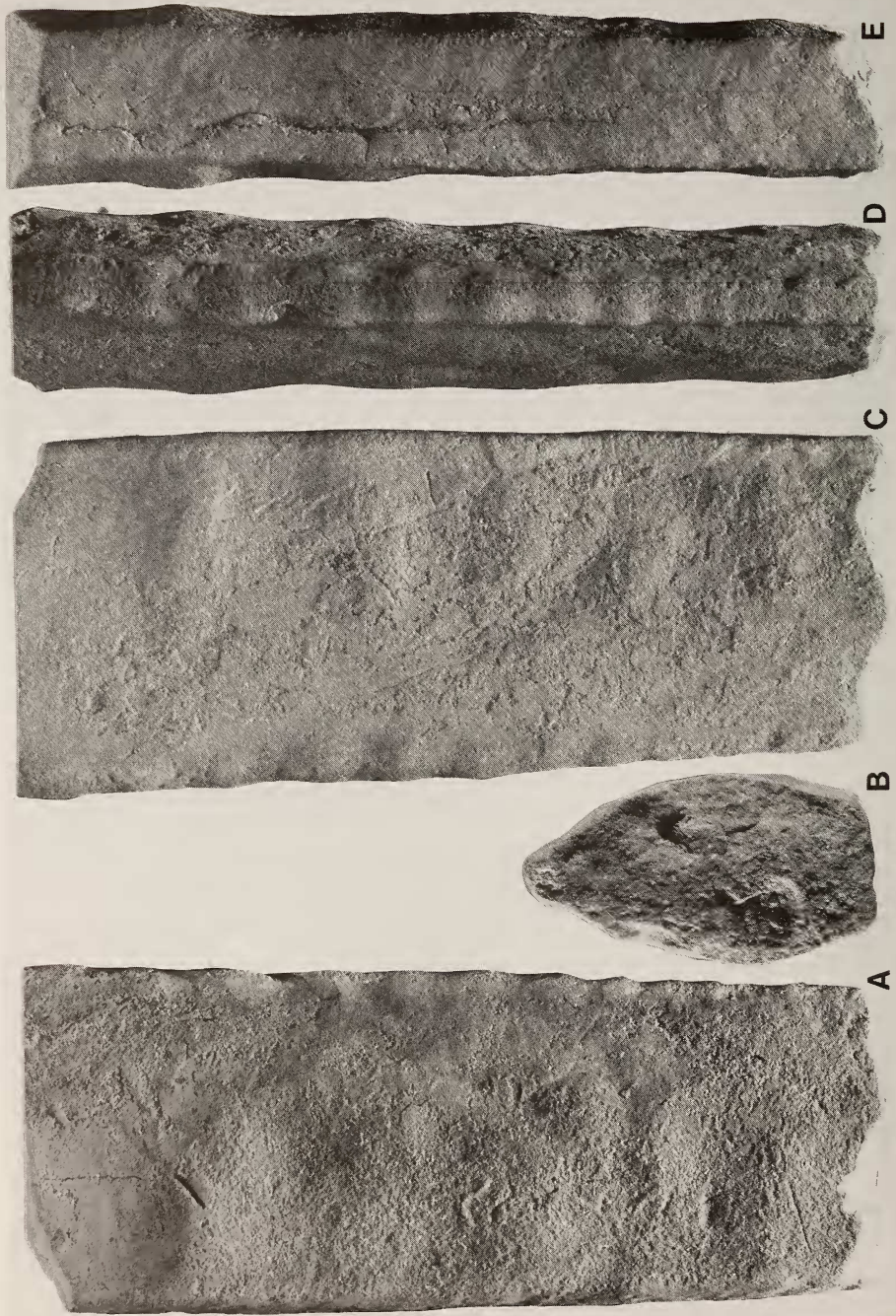


Fig. 27. *Eubaculites carinatus* (Morton, 1834), SAM-PCZ8651 (ex H63/1) weakly ornamented form, morphologically transitional to *E. latecarinatus*. From locality 133, Zululand, St Lucia Fm., Maastrichtian I. $\times 1$.

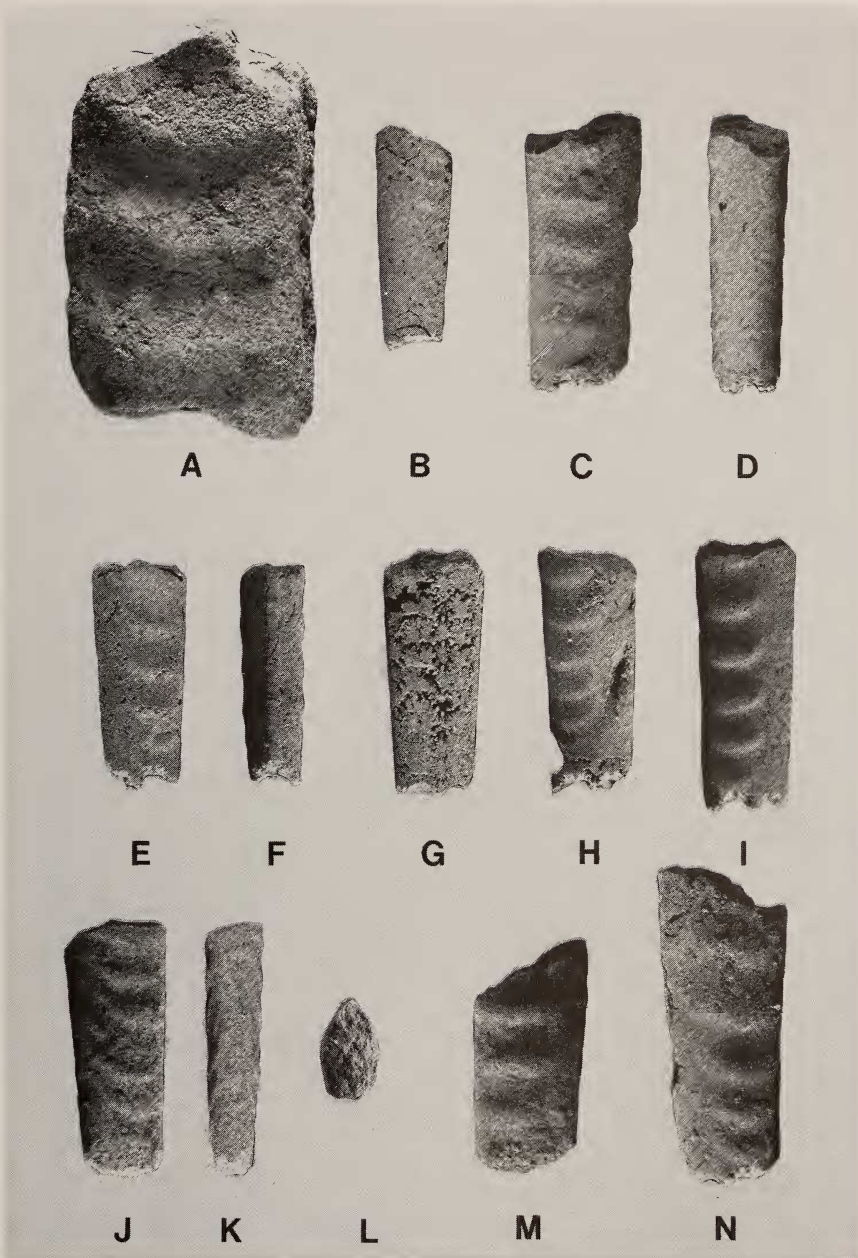


Fig. 28. *Eubaculites carinatus* (Morton, 1834). A. SAS H48/1 from locality 131, Zululand, St Lucia Fm, Maastrichtian II. B. SAM-PCZ8318. C-D. SAM-PCZ8319. E-F. SAM-PCZ8326. G. SAM-PCZ8324. H. SAM-PCZ8329, all from locality 134, Zululand, St Lucia Fm, Maastrichtian II. I. SAS H163G from Bed 7 (G) at locality 20. J-L. SAS Z2204a, specimen transitional to *E. simplex* from locality 133, Zululand, St Lucia Fm, Maastrichtian I. M. SAM-PCZ8320 from locality 134, Zululand, St Lucia Fm, Maastrichtian I. N. SAM-PCZ8323, from locality 134. All $\times 1$.

Parts of the suture line (from PCZ7047) are shown in Figure 38 and illustrated photographically in Figure 24A–C.

Discussion

The ribbed Zululand *Eubaculites* were originally identified by Kennedy & Klinger (1975: 281) and described as *E. ootacodensis* by Klinger (1976). However, as discussed above, this is a synonym of *E. labyrinthicus*, which has binodose flanks and a fastigiate venter at small diameter. In large specimens the lateral ornament of *E. labyrinthicus* and some of *E. carinatus* is virtually identical, and they can only be distinguished by their distinct fastigiate venter and tabulate ventral keels, respectively (compare e.g. Fig. 36A–D and Fig. 35, specimens from Madagascar). In typical specimens, *E. carinatus* is easily identified in the adult stage by the conspicuous crescentic flank ribbing. *Eubaculites vagina* has a similar, sometimes more angular whorl section, but ornament typically consists of two distinct rows of tubercles—one at mid-flank and the other near the dorsolateral edge. *Eubaculites latecarinatus* differs from *E. carinatus*, typically having smooth flanks. However, smooth specimens of *E. carinatus* do occur (see Kennedy & Summesberger 1986, pl. 14 (figs 6–8)). Individually these are indistinguishable from *E. latecarinatus*, and smooth variants of *E. vagina*, but populations are distinct enough.

We have a number of small specimens that are weakly ribbed to smooth but with compressed whorl section, with Wb : Wh ratio of 0.4–0.5. Klinger (1976) referred these compressed specimens to *E. compressum* Brunnshweiler, 1966. *Eubaculites compressum*, as interpreted by Klinger (1976), included Brunnshweiler's (1966) *Eubaculiceras* and *Cardabites* species. This is a rather mixed bag containing costate (*Eubaculiceras*) and non-costate (*Cardabites*) forms, some with tabulate venter, e.g. *Eubaculiceras compressum* (sensu Brunnshweiler 1966), *Cardabites tabulatus*, and others with fastigiate venter, e.g. *Eubaculiceras fastigiatum* and *Cardabites scimitar*. SAS H60F/2 (Klinger 1976, pl. 43 (fig. 13)) shows the transition from a fastigiate venter at one end to tabulate at the other. They all have in common a compressed whorl section with Wb : Wh ratio of less than 0.5. Henderson *et al.* (1992) restudied the Australian material, and also regarded all of these species as synonyms (plus *Baculites* sp. of Hünicken 1965: 64, pl. 2 (figs 3–4), pl. 3 (figs 5–6), pl. 5 (fig. 5), pl. 6 (figs 6–7), pl. 8 (figs 2–5) and *Eubaculites simplex* Kossmat of Collignon (1971: 15, pl. 645 (figs 2388–2389)), for which they used the name *Eubaculites simplex* Kossmat, 1895 (*pars*, p. 156, pl. 19 (fig. 13 non 14)). The lectotype is shown in Figure 7I–K. The Australian material is very compressed, smooth or with faint dorsal undulations and a narrowly fastigiate to narrowly tabulate venter.

Of all the species of *Eubaculites* recognized, *E. carinatus* has the longest stratigraphic range, through much of the Lower and Upper Maastrichtian. Assemblages of *E. carinatus* from different geographic regions and different stratigraphic levels all show a very wide range of variation. The excellent illustrations by Hünicken & Covacevich (1975) of the Quiriquina material (Fig. 37) and West Australian material, described and figured by Brunnshweiler (1966) and Henderson *et al.* (1992), show the wide variation in density and strength of ribbing of *E. carinatus*. Brunnshweiler (1966: 32, pl. 3 (figs 8–12), text-fig. 16) named the more densely ribbed forms *E. multicostatus*. Kennedy & Summesberger (1986: 197, pl. 14 (figs 6–8)) figured an almost smooth individual of *E. carinatus* (as *E. lyelli*) from the Maastrichtian of Neuberg, Steiermark, Austria.

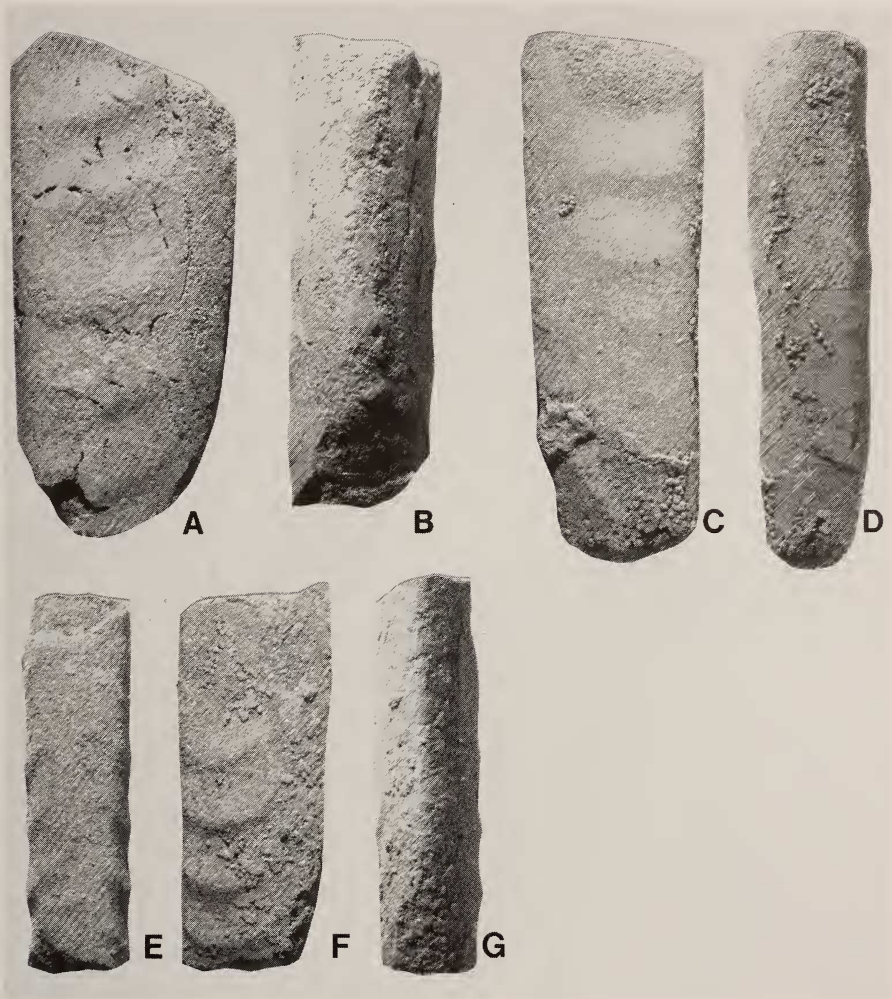


Fig. 29. *Eubaculites carinatus* (Morton, 1834). A-B. OUM KX1836. C-D. OUM KX1837.
E-G. OUM KX1835. All from locality 133, Zululand, St Lucia Fm, Maastrichtian I.
All $\times 2$.

Kossmat (1897b: 73) noticed that 'The Chilean *Baculites vagina* is recognizable by the fact that the swellings of the ribs are a little nearer to the siphonal part of the shell than in the Indian type, for this reason the section appears to be more oval.' We do not know if Kossmat had Indian *Eubaculites carinatus* or *E. ootacodensis* in mind when making this statement. Both Indian *E. ootacodensis* figured by Stoliczka (1866, pl. 90 (fig. 14)) and *E. carinatus* figured by Kossmat (1895, pl. 19(5) (fig. 16)) do show the ribs to be most strongly developed near the dorsal edge, but we do not know if this is a constant feature of Indian *E. carinatus*, for there are not enough illustrations of Indian material to substantiate this view.

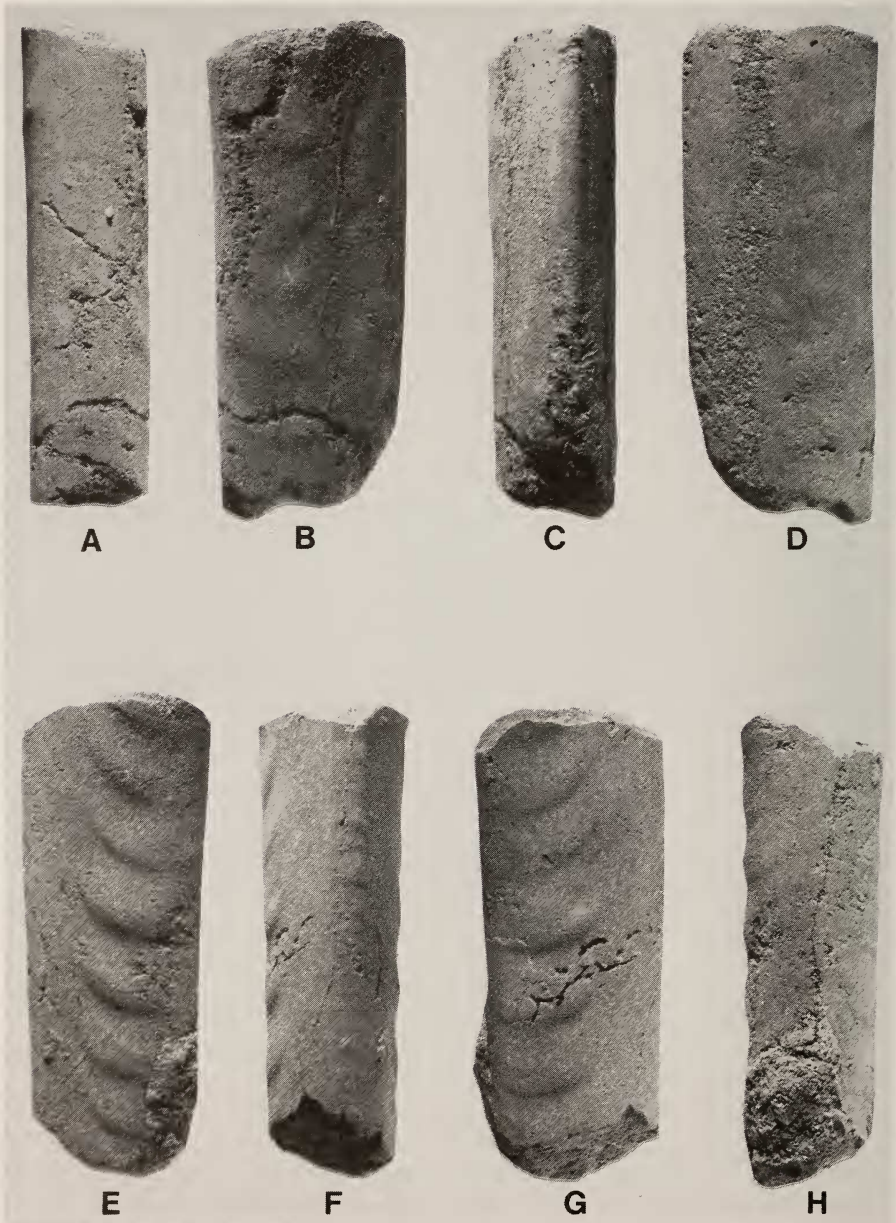


Fig. 30. *Eubaculites carinatus* (Morton, 1834). A-D. OUM KX1839. E-H. OUM KX1840. Both from Bed 7 (G), locality 20, Zululand, St Lucia Fm, Maastrichtian II. Both $\times 2$.

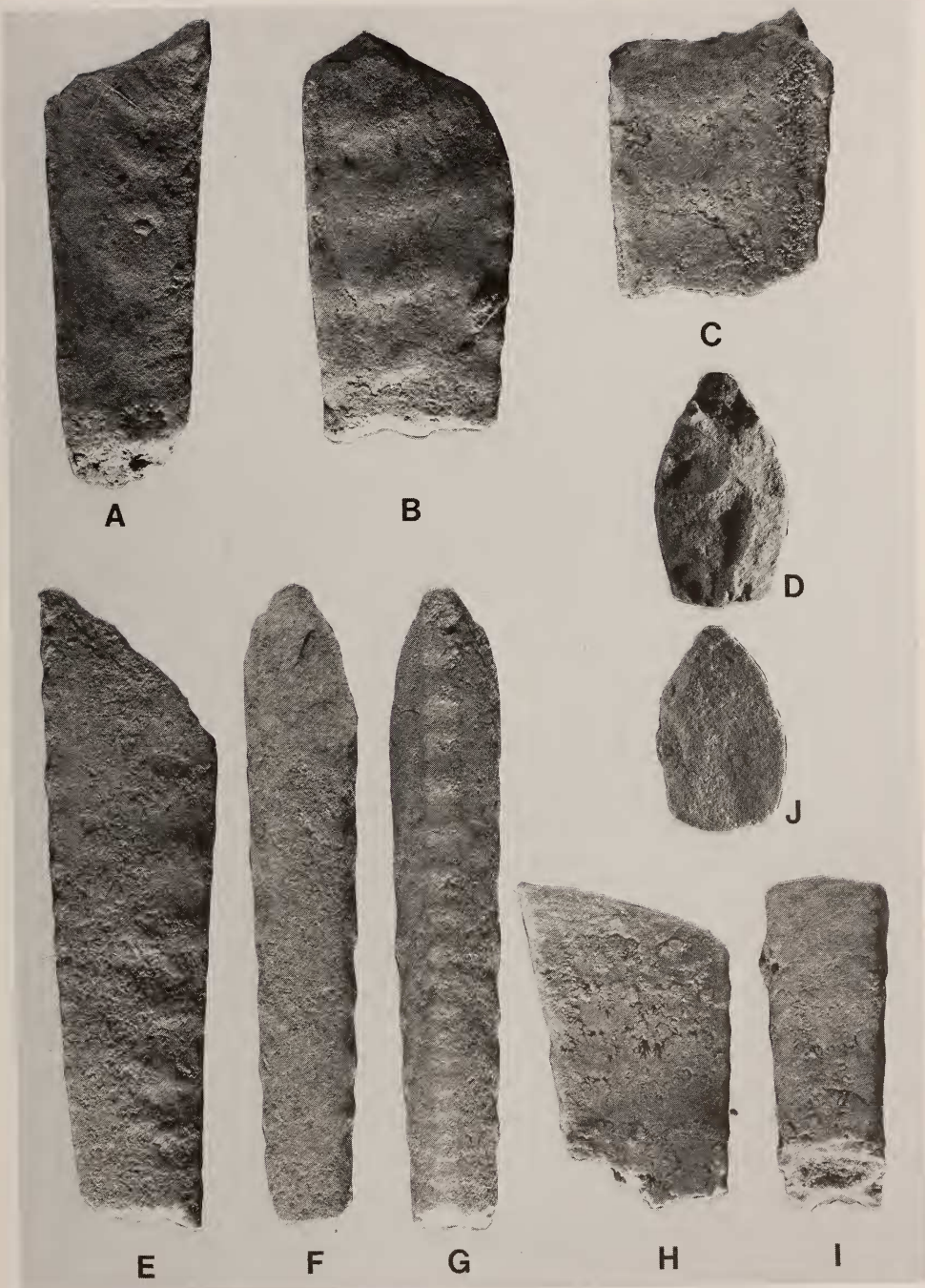


Fig. 31. A–G. *Eubaculites carinatus* (Morton, 1834). A. SAS H20/5 from Bed 5 (E) at locality 20, Zululand, St Lucia Fm, Maastrichtian II. B. SAS H63/12 from locality 133, Zululand, St Lucia Fm, Maastrichtian I. C–D. SAS H60H/17 from Bed H at locality 133. E–G. SAS H54/11 from locality 132, Zululand, St Lucia Fm, Maastrichtian I. H–J. *Eubaculites latecarinatus* (Brunnschweiler, 1966), SAS H61/13 from locality 133. All $\times 1$.

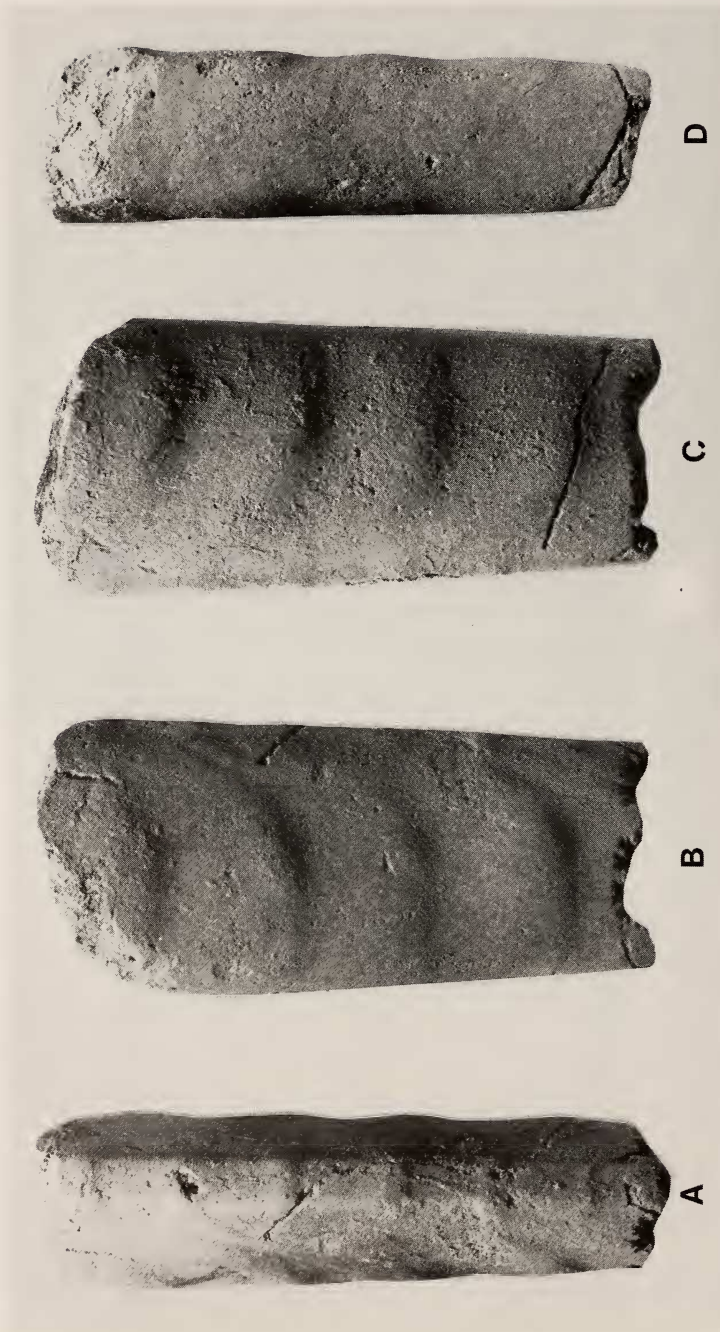


Fig. 32. *Eubaculites carinatus* (Morton, 1834). A-D. OUM KX1827 from Bed 7 (G), locality 20, Zululand, St Lucia Fm., Maastrichtian II. $\times 2$.

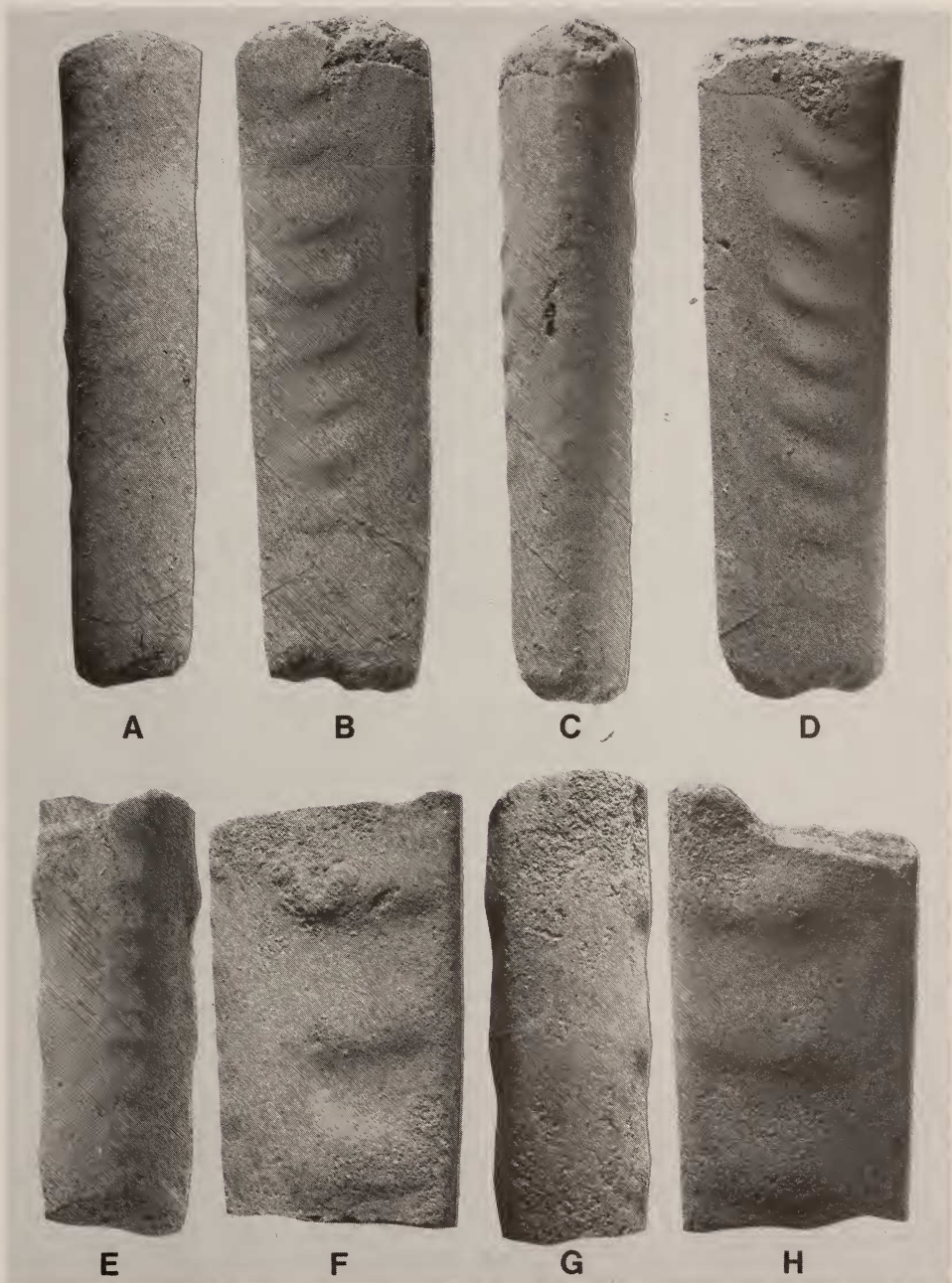


Fig. 33. *Eubaculites carinatus* (Morton, 1834). A–D. OUM KX1826. E–H. OUM KX1825. Both from Bed 7 (G), locality 20, Zululand, St Lucia Fm, Maastrichtian II. Both $\times 2$.

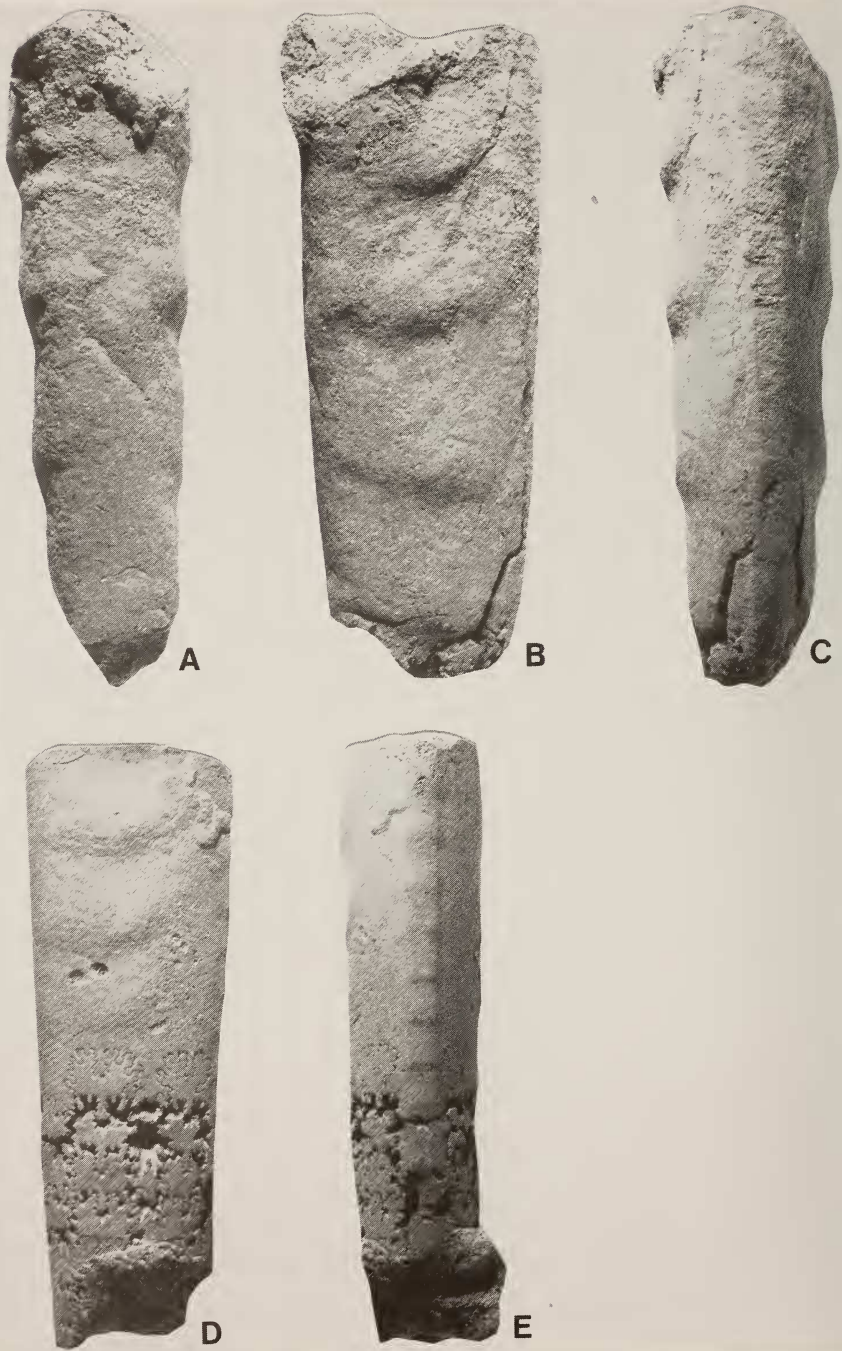


Fig. 34. *Eubaculites carinatus* (Morton, 1834). A-C. OUM KX1834 from Bed 4, locality 20, Zululand, St Lucia Fm, Maastrichtian I-II. D-E. OUM KX1838, from locality 133, Zululand, St Lucia Fm, Maastrichtian I. All $\times 2$.

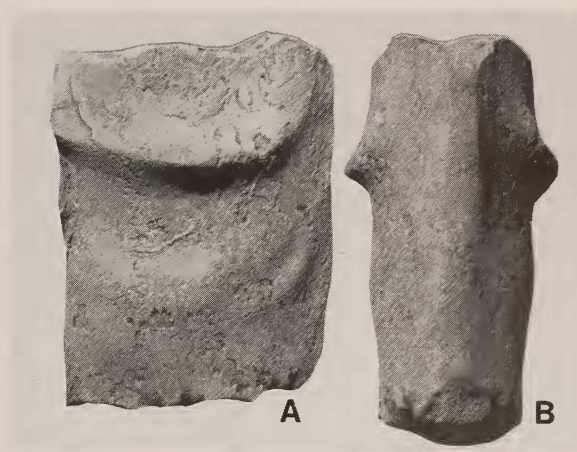


Fig. 35. *Eubaculites carinatus* (Morton, 1834). The original of Collignon's (1971, pl. 646 (fig. 2395)) *Eubaculites otacodensis* from locality 503-504, Soatana-Mikoboka (Manera), Madagascar. Note similarity of lateral ornament to that of large *E. labyrinthicus*, also from Madagascar in Figure 36A-D.

As in *E. latecarinatus*, there is great variation in the absolute size of *E. carinatus*. Some of the Argentinian specimens before us (Fig. 36F) are as large as the largest *E. latecarinatus* we have seen.

The specimens from Mozambique identified by Crick (in Teale 1924: 139) as belonging to the group of *Baculites vagina* include ribbed forms that probably belong to the present species.

Eubaculites carinatus has not been previously recorded from Madagascar, but the original of Collignon's (1971) *E. otacodensis* in part belongs to the present species (Fig. 35).

Occurrence

Of the known species of *Eubaculites*, *E. carinatus* has the widest geographic distribution and is a good indicator for the Maastrichtian Stage. It first occurs in Zululand in Maastrichtian a, associated with typical Lower Maastrichtian *Pachydiscus neubergicus*—as it also does at Neuberg, Steiermark in Austria—and ranges to Maastrichtian II in Zululand, and the upper Upper Maastrichtian in the Petites-Pyrénées in southern France, as well as in coastal sections in the Biscay region. *Eubaculites carinatus* is abundant in the Southern Hemisphere in the South Gondwanid Province, where it has been recorded from South India, Western Australia, Zululand, Mozambique, Madagascar, possibly Angola (Fig. 55F-H), Chile and Argentina. In the Northern Hemisphere it is common in the Owl Creek, Prairie Bluff and Corsicana Formations in Missouri, Mississippi, Alabama, and Texas, and is rare as remanié fossils at the base of the Palaeocene in New Jersey. It also occurs, albeit not in such great numbers, in California, the Netherlands, south-east France, northern Spain and Austria.

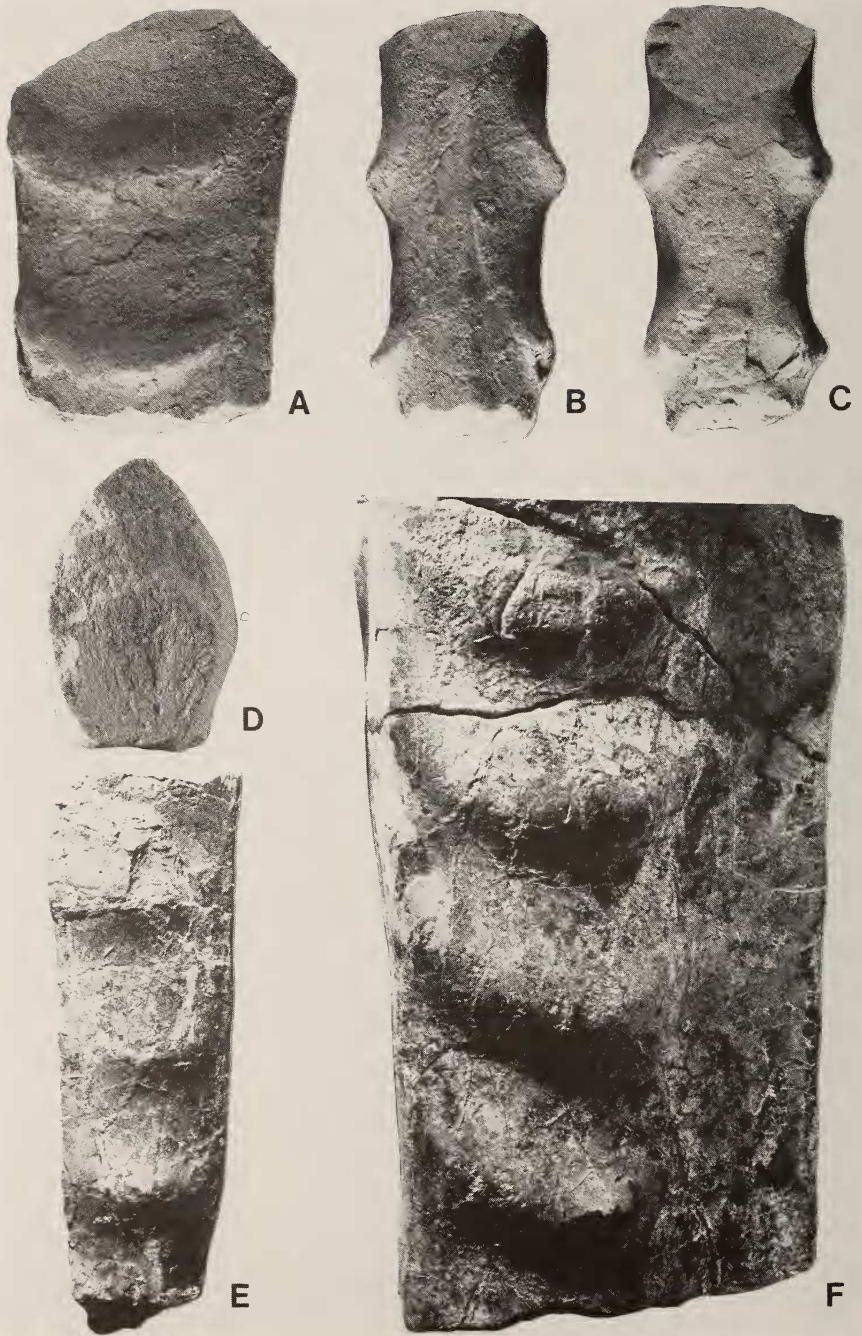


Fig. 36. A-D. *Eubaculites labyrinthicus* (Morton, 1834). Specimen from locality 503, Soatana-Mikoboka (Manera), Madagascar, donated by the late Gen. M. Collignon. E-F. *Eubaculites carinatus* (Morton, 1834). Two specimens from Neuquén Basin, Argentina. Collections of the División Paleozoología de Invertebrados, Museo de Ciencias Naturales, Universidad Nacional de la Plata, Argentina; courtesy Dr A. C. Riccardi. All $\times 1$.



Fig. 37. *Eubaculites carinatus* (Morton, 1834). Block of specimens from Quiriquina Island, Chile. Collection of Museum für Naturkunde, Berlin. $\times 1$.

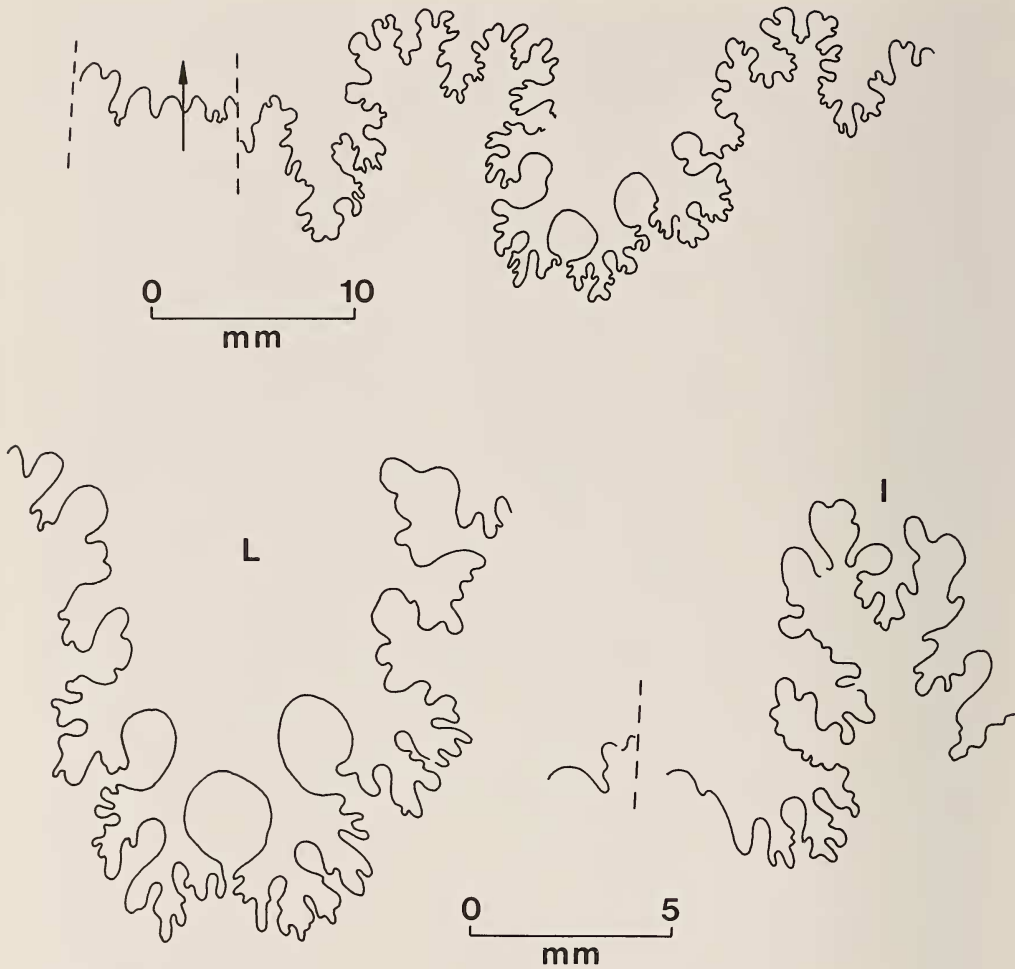


Fig. 38. *Eubaculites carinatus* (Morton, 1834). Part of suture line of SAM-PCZ7047.

Eubaculites latecarinatus (Brunnschweiler, 1966)

Figs 26A, 39–41, 42B–C, 43–49, 50A, 53A

Eubaculites otacodensis (Stoliczka): Spath, 1940: 49 (*pars*), text-fig. 1c.

Giralites latecarinatus Brunnschweiler, 1966: 33, pl. 3 (figs 13–14), pl. 4 (figs 1–5), text-figs 17–18.

Giralites quadrisulcatus Brunnschweiler, 1966: 35, pl. 4 (figs 11–14), text-fig. 20.

Eubaculites ambindensis Collignon, 1971: 18, pl. 646 (fig. 2393).

Baculites occidentalis Meek: Collignon, 1971: 15, pl. 645 (fig. 2390).

Eubaculites latecarinatus (Brunnschweiler): Klinger, 1976: 91, pl. 40 (figs 1–2), pl. 41 (fig. 3), pl. 42 (figs 2, 6), pl. 43 (figs 3–4), text-fig. 11d–e. Klinger & Kennedy, 1980: 296, figs 2–4, 5D. Henderson *et al.*, 1992: 159, figs 22L–N, 23N–P.

Type

Holotype is the original of Brunnschweiler (1966, pl. 4 (figs 2–4)), CPC 2718 from the nodule bed at the top of the Korojong Calcarenite; Western Australia.

Material

Numerous specimens, including SAS H163D, Bed 4 (D), SAM-PCZ7938, Bed 7 (G) at locality 20, section at junction of old course of the Mfolozi River, the present course and the unnamed stream draining south from Lake Mfuthululu, St Lucia Formation, Maastrichtian I-II; SAM-PCZ7029, PCZ7041-7045, PCZ7048-7056, PCZ7064, PCZ7072, PCZ7074, PCZ7172-7176, PCZ7291-7298, PCZ7975, PCZ7979, SAS H60, H60/1.2, H61/6, H61/13, H62/5, all from locality 133; SAS H60F/11 from Bed F at locality 133; SAS H60H, H60H/1, H60H/4, Bed H at locality 133, cliff section and beach platform below Charter's Creek Rest Camp, Lake St Lucia, Zululand, St Lucia Formation, Maastrichtian I; SAM-PCZ7038, PCZ7058-7059, PCZ7061, SAS H54B/15, Bed B, from locality 132, degraded cliff and foreshore platform 300 m north-east of northern jetty at Charter's Creek Rest Camp, Lake St Lucia, Zululand, St Lucia Formation, Maastrichtian I; SAM-PCZ7065-7066, PCZ7068-7069, PCZ7075, PCZ7429, PCZ7432, PCZ7709, PCZ7980, PCZ8320-8330, PCZ8457-8458, SAS Z2204 from locality 134, cliffs and foreshore section, 1,2 km south of Charters Creek Rest Camp, St Lucia Formation, Maastrichtian I; SAS L97 from locality 131, low cliff and foreshore section 4,6 km north of Charter's Creek Rest Camp, St Lucia Formation, Maastrichtian II; SAM-PCO5908-5914, all from locality C in the Alphard Group, offshore, Cape Province, Maastrichtian ?a.

Dimensions

<i>Specimen</i>	<i>Wb</i>	<i>Wh</i>	<i>Wb/Wh</i>	<i>Tapering</i>
SAS Z2204	19	28	0,68	—
SAS H60F/11	12,5	19	0,66	—
	10	16	0,62	9,7 (D = 13)
SAS H61/6	18	25	0,7	—
SAS H61/13	17	27	0,63	—
	14	23	0,61	16 (D = 25)
SAS H62/5	18	26	0,69	—
	13	19	0,68	14,2 (D = 49)
SAS H60/1.2	—	52	—	—
		41		5,2 (D = 210)
SAM-PCZ7068	27	44	0,61	—
SAM-PCZ7069	29	49	0,59	—
	24	44	0,54	6,5 (D = 77)
SAS H54B/15	46	72	0,64	—
	40	65	0,61	6,0 (D = 117)
SAM-PCZ7269	—	65	—	—
		64		0,41 (D = 240)
SAM-PCZ7066	—	68	—	—
		66		2,3 (D = 88)
SAM-PCZ7980	—	90	—	—
		82		4,6 (D = 172)
SAS H163D	28	44	0,63	—
	19	28	0,69	12,6 (D = 125)

SAS H60	—	68	—	
		77		3,1 (D = 290)
SAM-PCZ7298	—	88	—	
		57		3,9 (D = 800)

Diagnosis

Eubaculites with tabulate ventral keel; no lateral ornament. May grow to a large size.

Description

Tapering in the early stages is rapid, but decreases with growth, such that large specimens have venter and dorsum essentially parallel in side view. The whorl section in the adult stage is distinctly pyriform with a broad, flat dorsum and a serrated, tabulate keel. The flanks are slightly inflated and nearly parallel. Maximum width is at, or just ventral of, mid-flank. A distinct longitudinal ridge at the middle of the dorsum is present in some specimens. The flanks are completely smooth. The suture is minutely frilled with phylloid foliole elements in the saddles.

Discussion

This species is characterized by its tabulate venter and smooth flanks. It is the commonest *Eubaculites* in Zululand, and is conspicuous by virtue of its large size—the estimated length of some specimens was in excess of 2 metres.

Specimens reach maturity at large and small whorl heights, indicating size-related dimorphism—compare, e.g. Figures 39, 40 and 41. Unfortunately, complete apertures are very rare in the available material; part of one is preserved in H60H/1 (Fig. 46).

Smooth individuals of *E. vagina* (e.g. Stoliczka 1866, pl. 90 (fig. 1); herein Figs 15A–C, I–J, 16) and of *E. carinatus* (Kennedy & Summesberger 1986, pl. 14 (figs 6–8)) occur and are inseparable from *E. latecarinatus*, apart perhaps from details in whorl section. Populations of the species are easily distinguished, as discussed above.

The specimen figured by Collignon (1971: 15, pl. 645, (fig. 2390)) as *Baculites occidentalis* Meek seems to be a juvenile specimen of *Eubaculites simplex* or *E. latecarinatus* (Fig. 55A–B).

We have been inclined to regard smooth and compressed *Eubaculites*, described by Klinger (1976: 92, pl. 43 (fig. 2)), as *E. compressum* as variants of the present species, but revision of the Australian material (Henderson *et al.* 1992) has shown *E. latecarinatus* and these compressed forms, for which the earliest available name is *E. simplex* (Kossmat, 1895), to be morphologically and stratigraphically separated. *Eubaculites simplex* is much more compressed than *E. latecarinatus*, may have feeble flank undulations or be smooth, and has a fastigiate to narrowly tabulate ventral keel.

Occurrence

Eubaculites latecarinatus is most abundant in Maastrichtian I of Zululand, but onshore extends into Maastrichtian II. It is imprecisely located in the Maastrichtian of the offshore Alphonse Group, but may appear as early as Maastrichtian a (ex Campanian IV). In Madagascar it occurs in the Lower Maastrichtian Zone of *Pachydiscus neubergicus* and *P. gollevillensis*. The occurrences in Western Australia can be dated no more precisely than Maastrichtian.



Fig. 39. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A-C. SAS H163D from Bed 4 (D) at locality 20, Zululand, St Lucia Fm, Maastrichtian I-II. $\times 1$.



Fig. 40. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A-B. SAS H60H/4 from Bed H, locality 133, Zululand, St Lucia Fm, Maastrichtian I. $\times 0,75$.

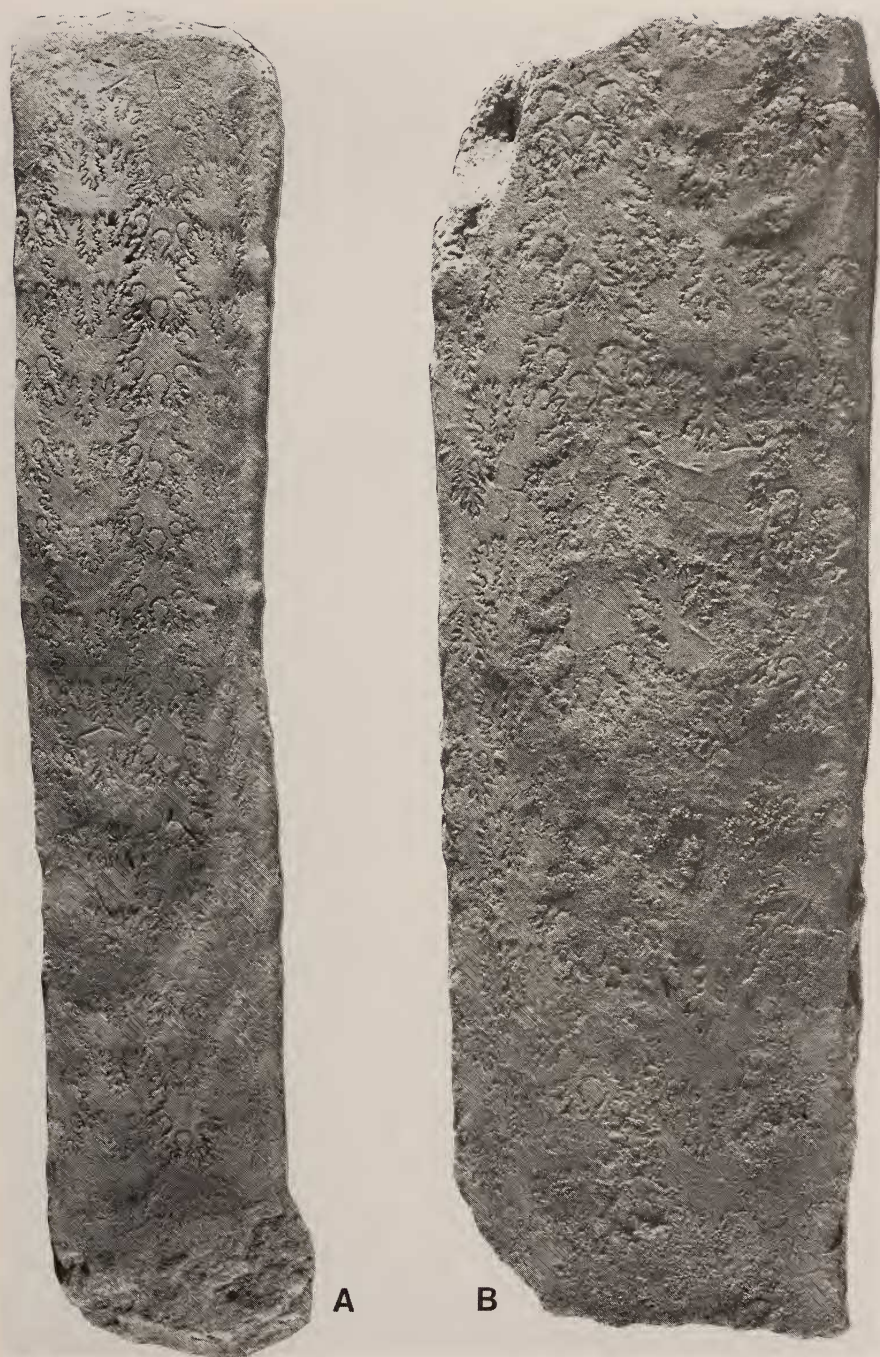


Fig. 41. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A. SAS H60H from locality 133, Zululand, St Lucia Fm, Maastrichtian I. B. SAS H54B/15 from Bed B at locality 132, Zululand, St Lucia Fm, Maastrichtian I. A $\times 0,40$; B $\times 0,85$.

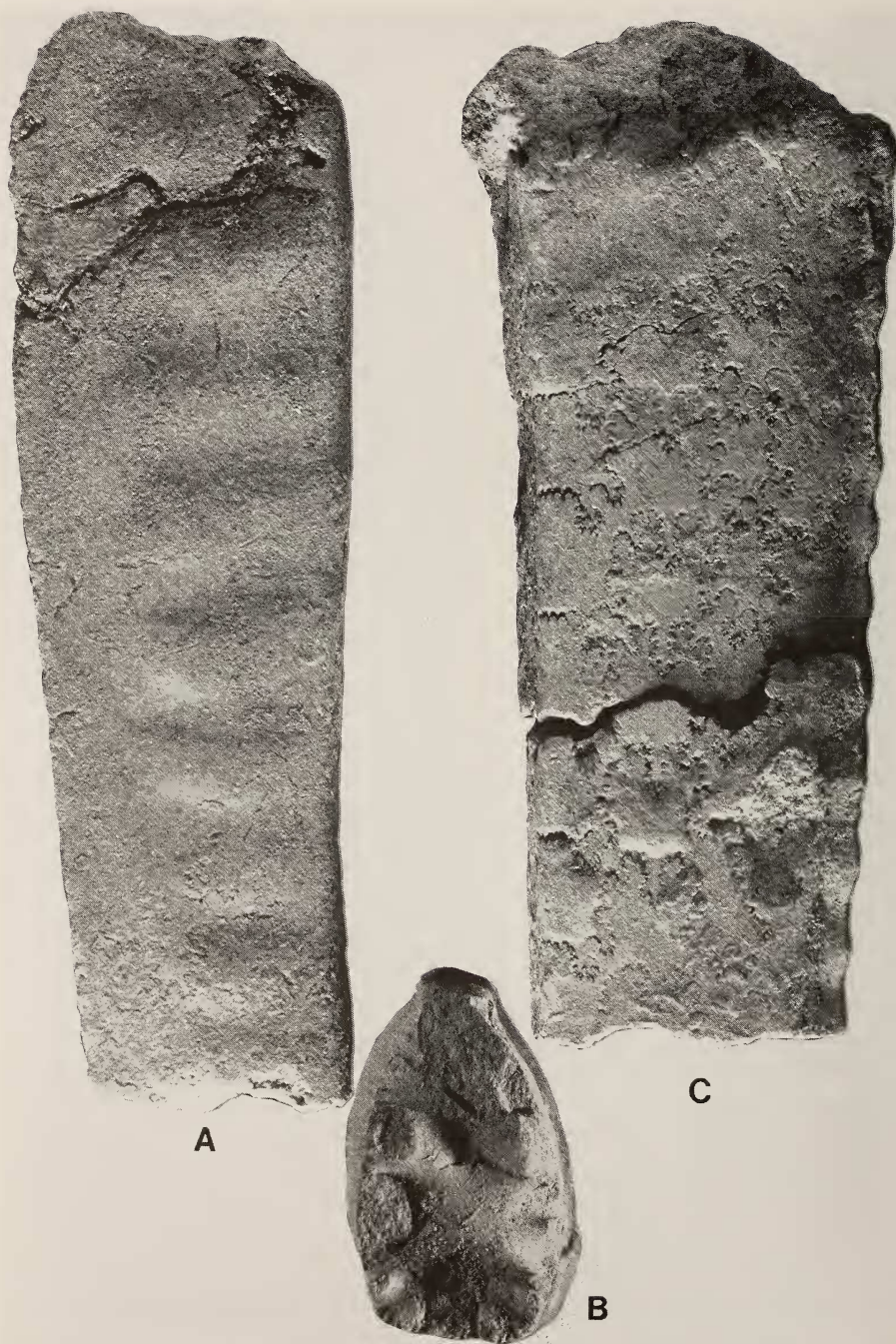


Fig. 42. A. *Eubaculites carinatus* (Morton, 1834). SAS L97, specimen with weak lateral ornament, transitional to *E. latecarinatus*, from locality 131, Zululand, St Lucia Fm, Maastrichtian II. B-C. *Eubaculites latecarinatus* (Brunnschweiler, 1966). SAM-PCZ7432 from locality 134, Zululand, St Lucia Fm, Maastrichtian I. Both $\times 1$.

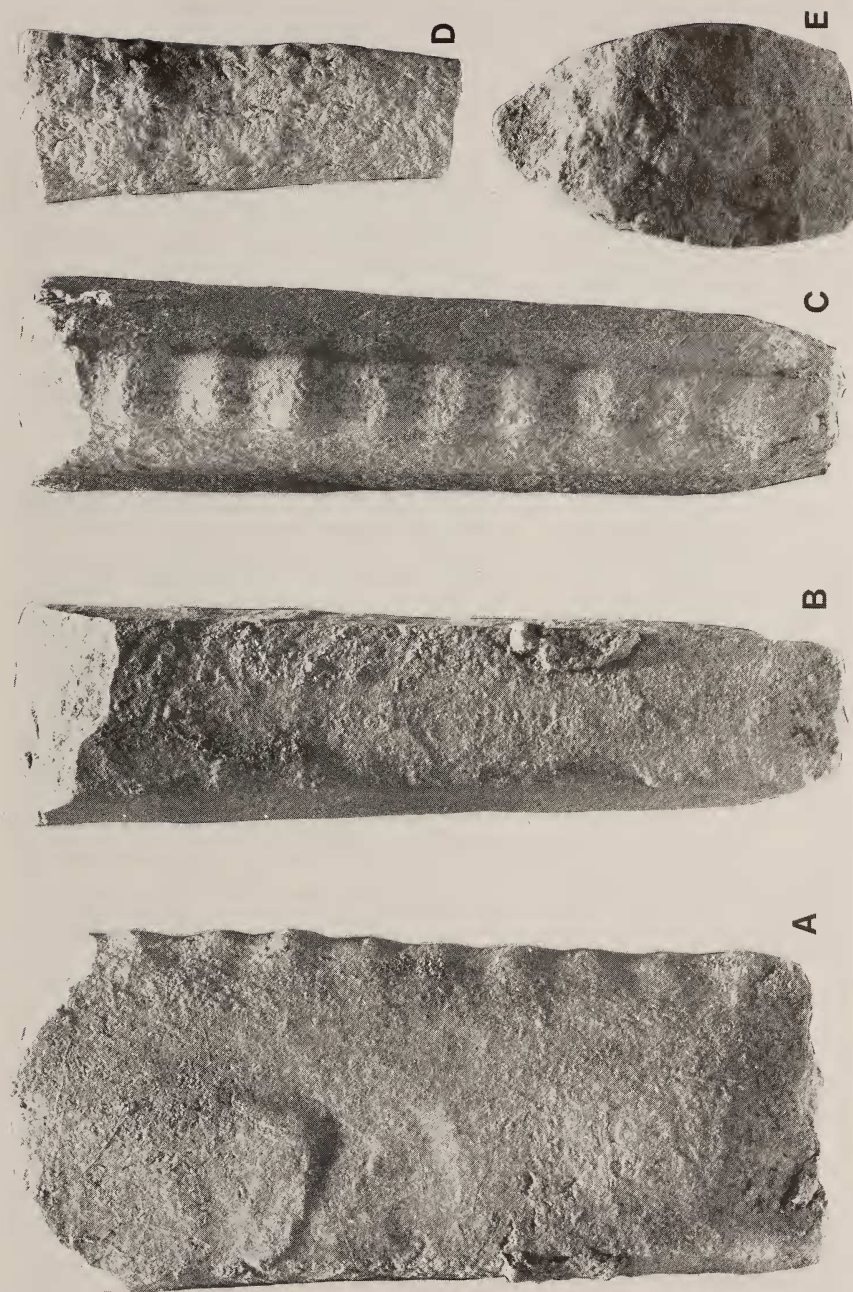


Fig. 43. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A-C, E, SAM-PCZ7069. D, SAM-PCZ8457. Both from locality 134, Zululand, St Lucia Fm, Maastrichtian I. Both $\times 1$.

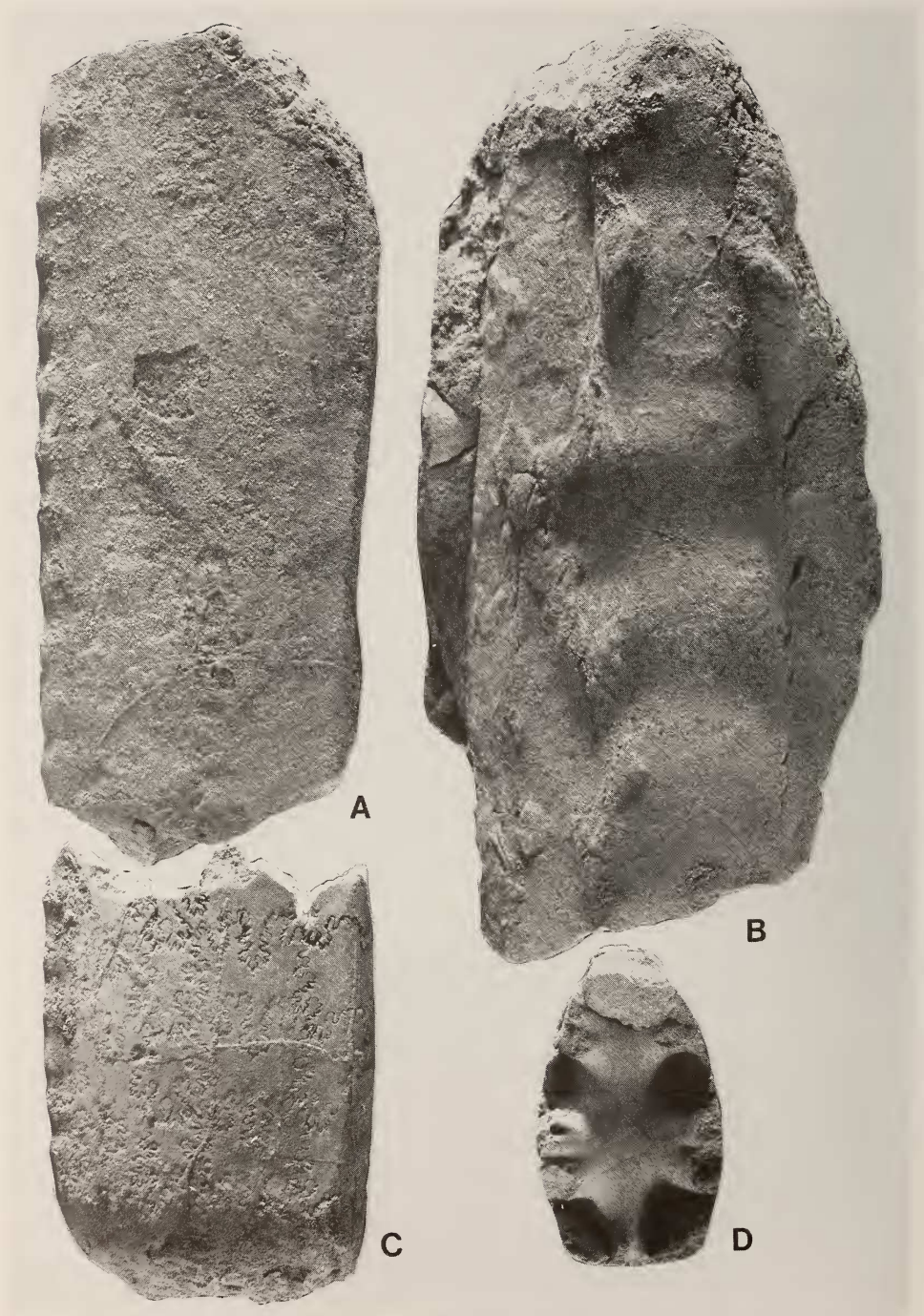


Fig. 44. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A. SAM-PCZ7068. B. SAM-PCZ8458, the largest known specimen, slightly deformed, viewed from the venter to show the size of the crenulate, tabulate venter. A-B. From locality 134, Zululand, St Lucia Fm, Maastrichtian I. C-D. SAM-PCZ7938; from Bed 7 (G) at locality 20, Zululand, St Lucia Fm, Maastrichtian I-II. All $\times 1$.

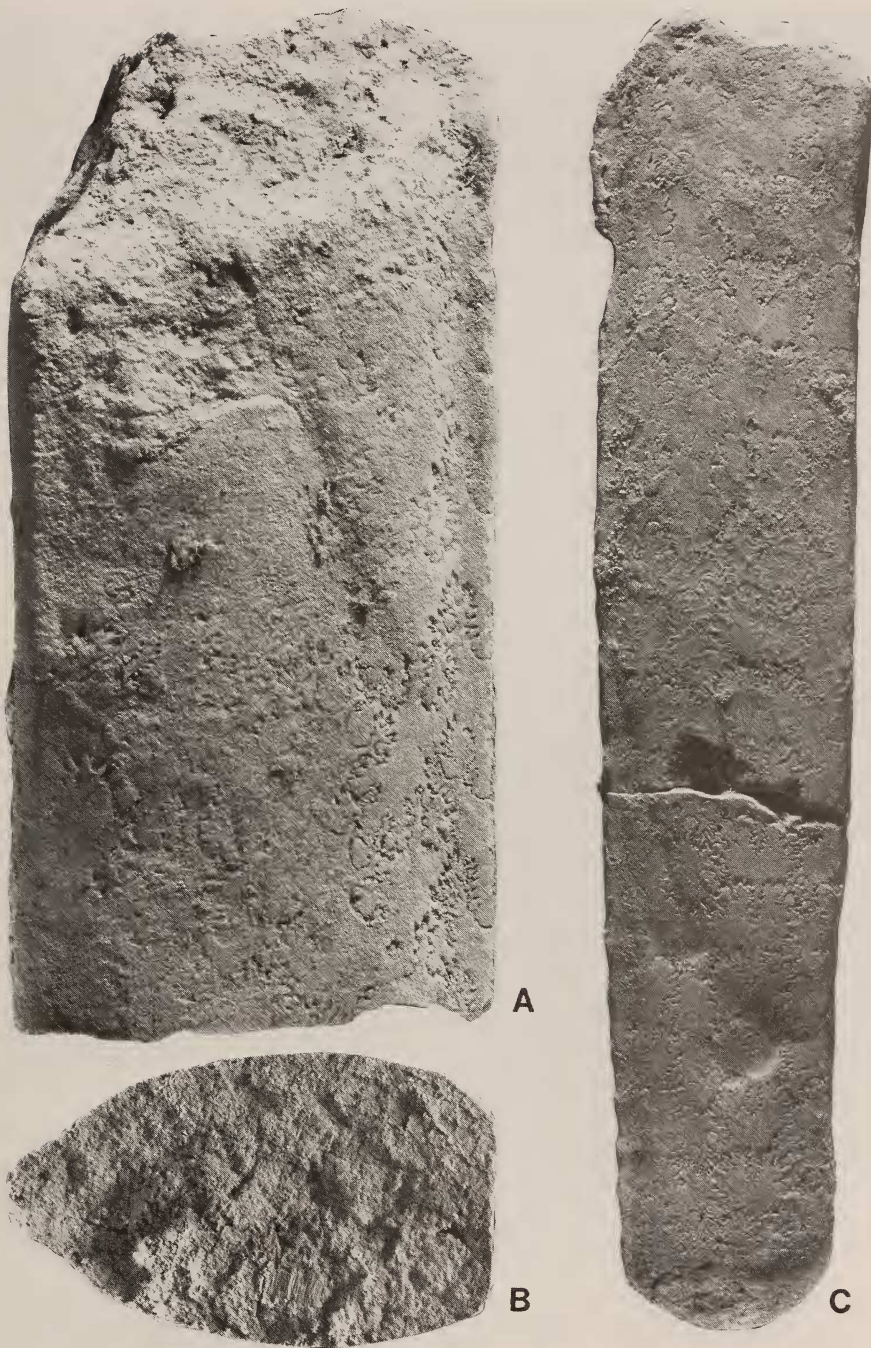


Fig. 45. *Eubaculites latecarinatus* (Brunschweiler, 1966). A-B. SAM-PCZ7975 from locality 133. C. SAS H54B/15 from Bed B at locality 132. Both from Zululand, St Lucia Fm, Maastrichtian I. A-B $\times 1$; C $\times 0,85$.



Fig. 46. *Eubaculites latecarinatus* (Brunschweiler, 1966). SAS H60H/1. Adult specimen with part of aperture preserved. Bed H, locality 133, Zululand, St Lucia Fm, Maastrichtian I. $\times 1$.

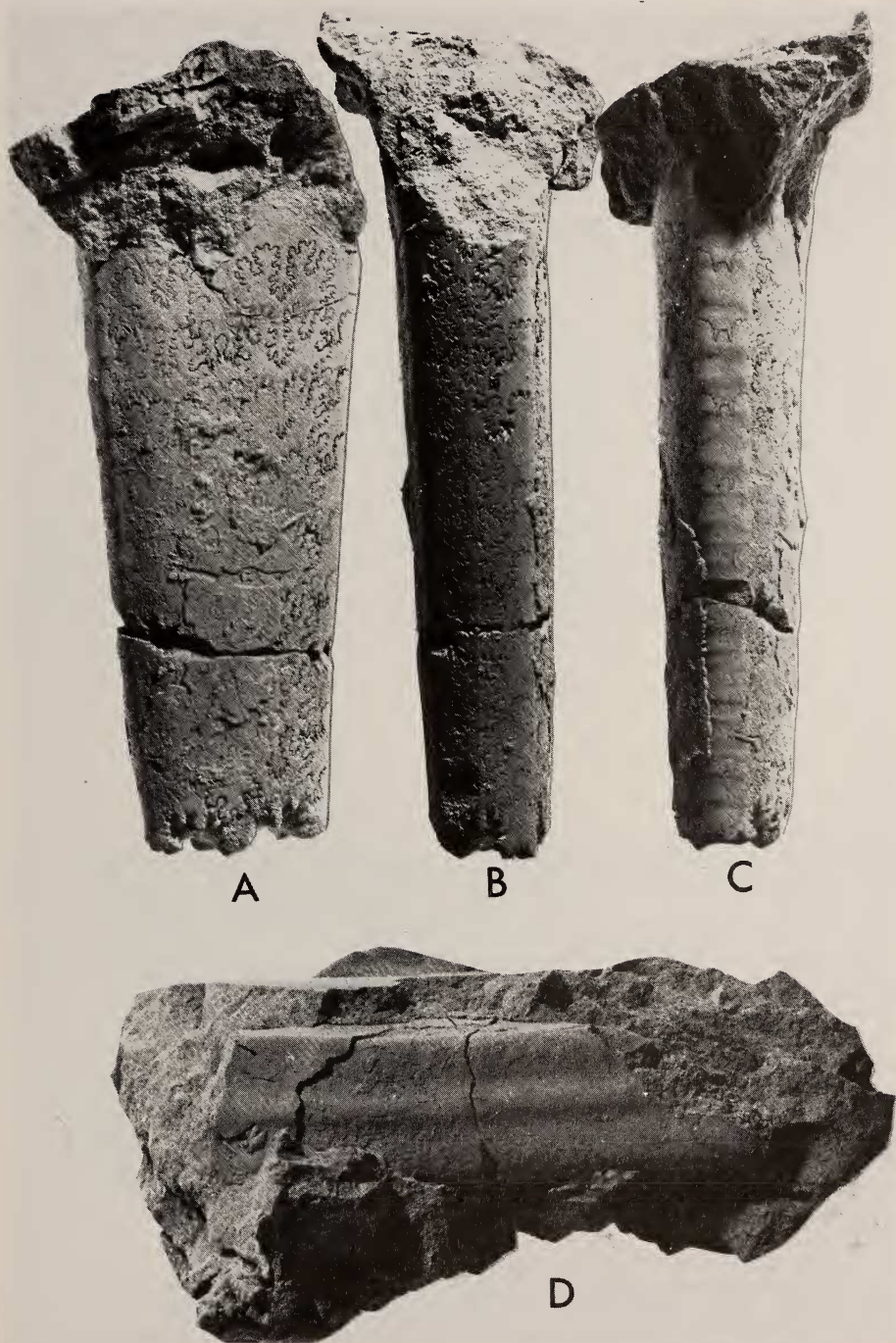


Fig. 47. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A-C. SAM-PCO5909. D. SAM-PCO5908; note the prominent median ridge on dorsal side. Both from locality C (TBD 1336) on the offshore Alphard Group, southern Cape, South Africa. $\times 1$.

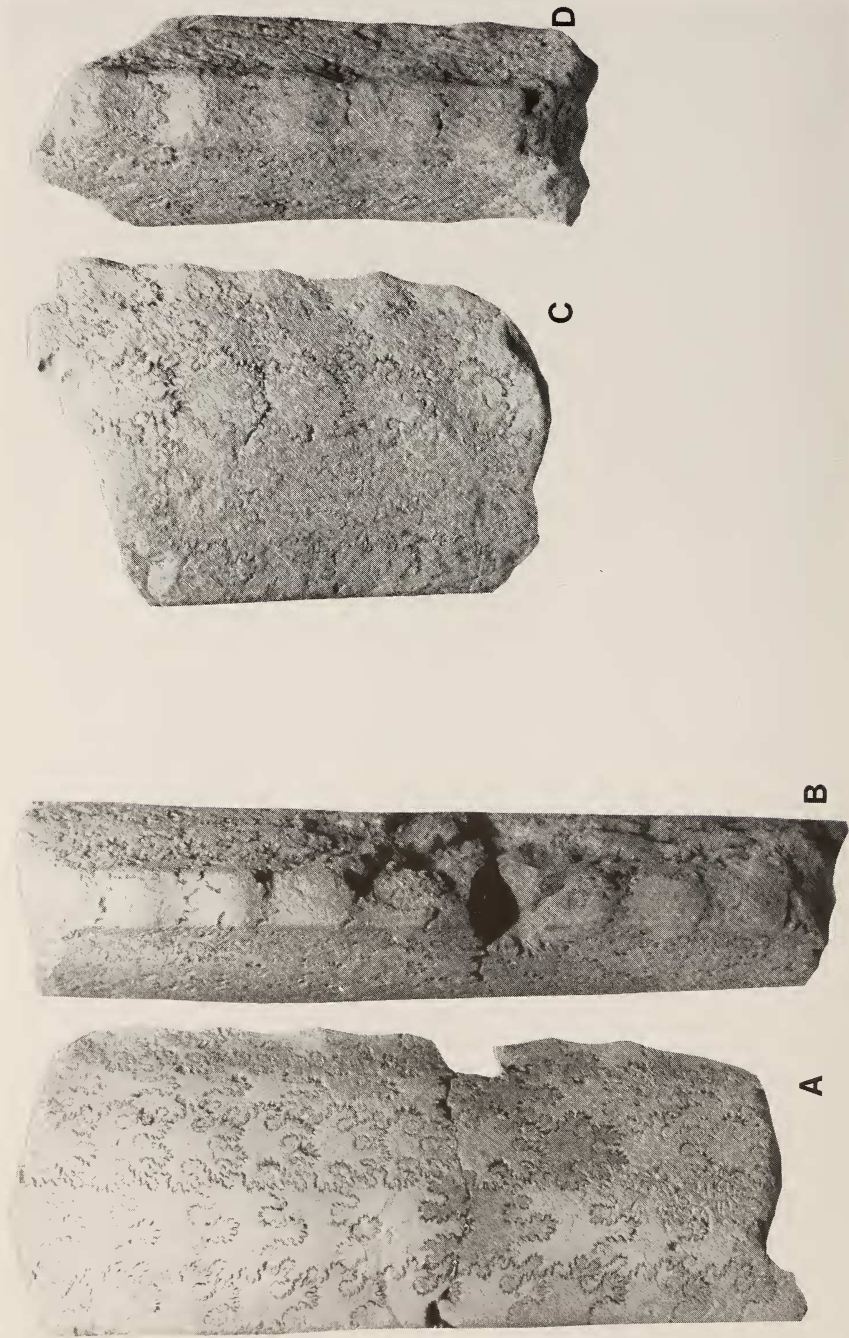


Fig. 48. *Eubaculites latecarinatus* (Brunnschweiler, 1966). A-B. The original of Collignon's (1971, pl. 646 (fig. 2393) *Eubaculites ambindensis* from locality 504, Mont Ambinda-Mikoboka (Manera), Madagascar. C-D. An unfigured syntype of Collignon's *Eubaculites ambindensis*. All $\times 1$.

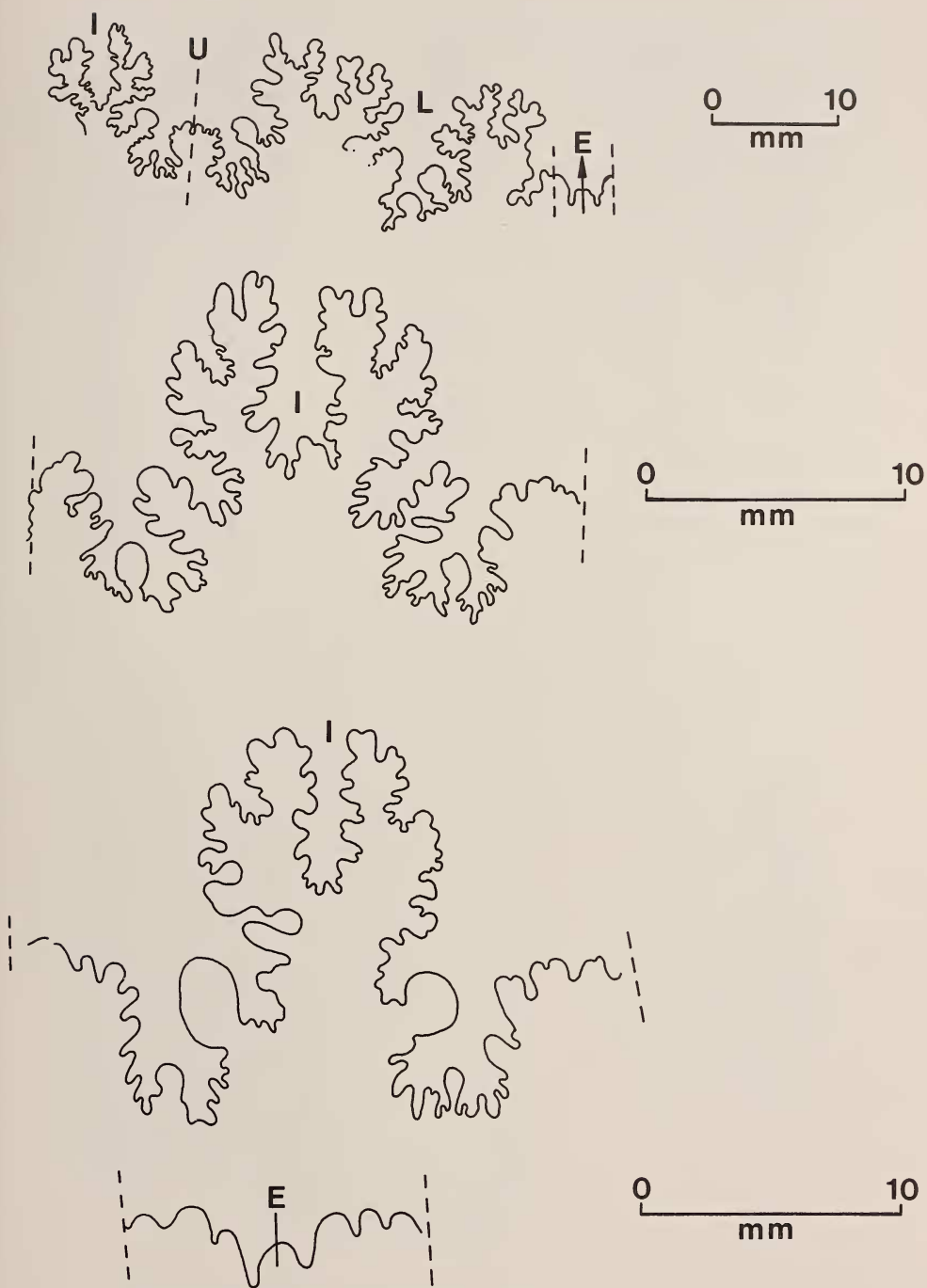


Fig. 49. *Eubaculites latecarinatus* (Brunnschweiler, 1966). Parts of the suture line.

Eubaculites simplex (Kossmat, 1895)

Figs 71–K, 50B, 51, 52D–F, I–N, 53B, 54–55

Baculites vagina Forbes n. var. *simplex* Kossmat, 1895: 156, pl. 19(5) (figs 13a–b) (*non* figs 14a–c) (= *E. carinatus*).*Baculites* sp. Hünicken, 1965: 64, pl. 2 (figs 3–4), pl. 3 (figs 5–6), pl. 5 (fig. 5), pl. 6 (figs 6–7), pl. 8 (figs 2–5).*Giralites simplex* (Kossmat): Brunnschweiler, 1966: 34, pl. 4 (figs 6–10), text-fig. 19.*Eubaculiceras compressum* Brunnschweiler, 1966: 36, pl. 4 (figs 15–17), pl. 5 (figs 1–3), text-fig. 21.*Eubaculiceras fastigiatum* Brunnschweiler, 1966: 37, pl. 5 (figs 7–9), text-fig. 22.*Cardabites tabulatus* Brunnschweiler, 1966: 38, pl. 5 (figs 12–15), text-fig. 23.*Cardabites scimitar* Brunnschweiler, 1966: 38, pl. 5 (figs 16–21), text-fig. 24.*Eubaculites compressum* (Brunnschweiler): Klinger, 1976: 92, pl. 42 (fig. 10a–b), pl. 43 (figs 2a–c, 13a–c, 14a–c).*Eubaculites simplex* (Kossmat): Henderson *et al.*, 1992: 153, 21, 22A–K, O–P, 23A–F, K–M, 24–25. Kennedy & Henderson, 1992: 717, text-fig. 6D–F.*Types*

Lectotype, designated by Kennedy (1986c: 195), is the original of Kossmat (1895, pl. 19 (figs 13a–b)), Geological Survey of India Type Collection, GSI 14819 (Fig. 71–K). The original of Kossmat (1895, pl. 19 (figs 14a–c)) is GSI 14820 in the same collections, and is a *Eubaculites carinatus*. Both are from the Arrialoor Group of Otacod, South India.

Material

SAS H163C/3 (Bed C), H163D/3 (Bed D), H163F/2 (Bed F), and SAM–PCZ7939 and PCZ7912 (Bed G) at locality 20, section at junction of the old course of the Mfolozi River, the present course, and the unnamed stream draining south from Lake Mfuthululu, St Lucia Formation, Maastrichtian I–II; SAS H66/2, H66/3, from locality 135, foreshore

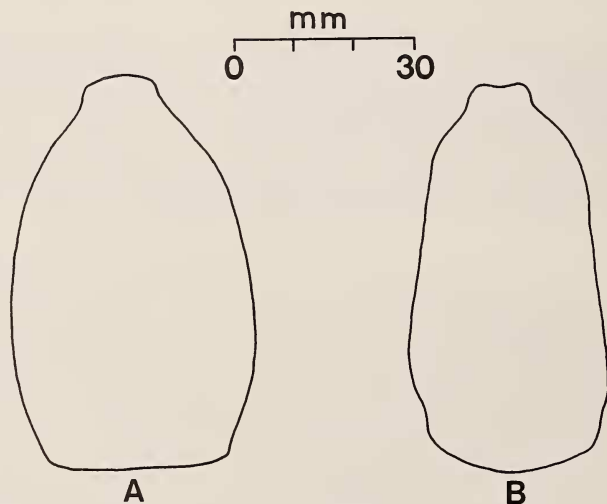


Fig. 50. Comparison of whorl sections of large examples of *Eubaculites latecarinatus* and *E. simplex*. A. *Eubaculites latecarinatus* (Brunnschweiler, 1966), SAM–PCZ7979. B. *Eubaculites simplex* (Kossmat, 1895), SAM–PCZ7939. Both $\times 1$.

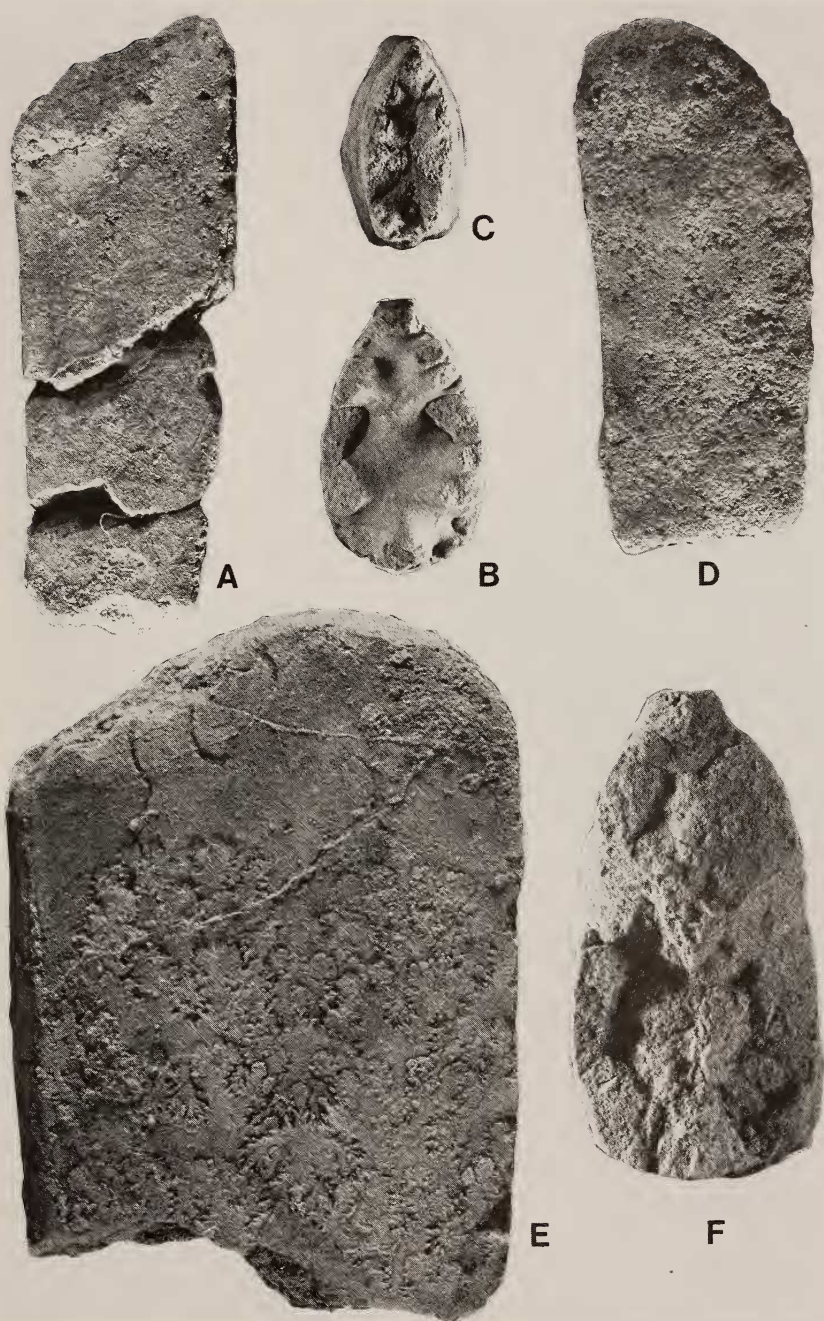


Fig. 51. *Eubaculites simplex* (Kossmat, 1895). A. SAS H163D/3 from Bed 4 (D). B. SAS Z2204m. C-D. SAS H163C/4 from Bed 3 (C). E-F. SAM-PCZ7939 from Bed 7 (G). All from locality 20, Zululand, St Lucia Fm, Maastrichtian I-II. All $\times 1$.

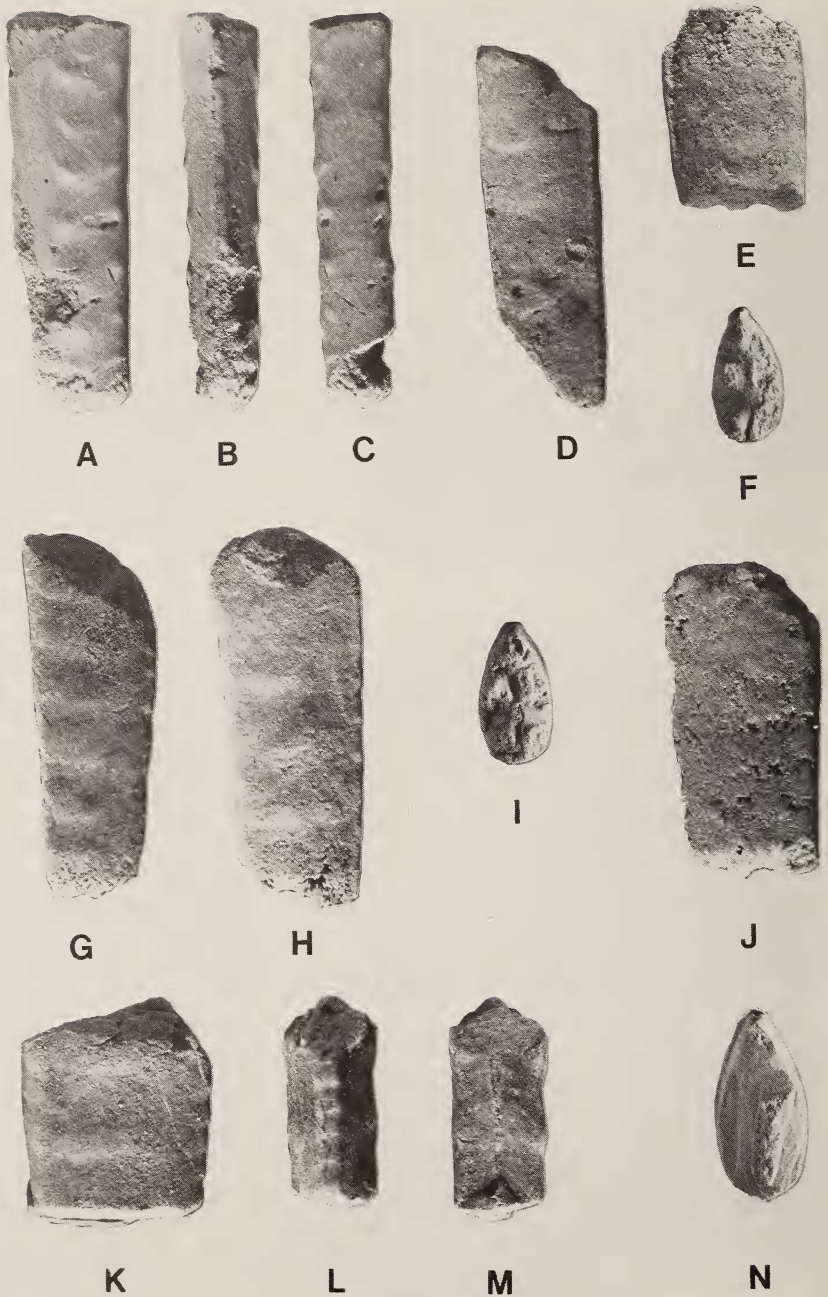


Fig. 52. A-C. *Eubaculites labyrinthicus* (Morton, 1834). SAS H163G/7 from Bed 3 (C) at locality 20, Zululand, St Lucia Fm, Maastrichtian I-II. D-F, I-N. *Eubaculites simplex* (Kossmat, 1895). D. SAS H66/2 from locality 135, Zululand, St Lucia Fm, Maastrichtian I. E-F. SAS H60F/12 from Bed F at locality 133, Zululand, St Lucia Fm, Maastrichtian I. I-J. SAS 163F/2 from Bed 6 (F) at locality 20. K-N. SAS Z2204c from locality 133. G-H. *Eubaculites carinatus* (Morton, 1834). G. SAM-PCZ8311, loose from locality 20. H. SAS H163D/1 from Bed 4 (D) at locality 20. All $\times 1$.

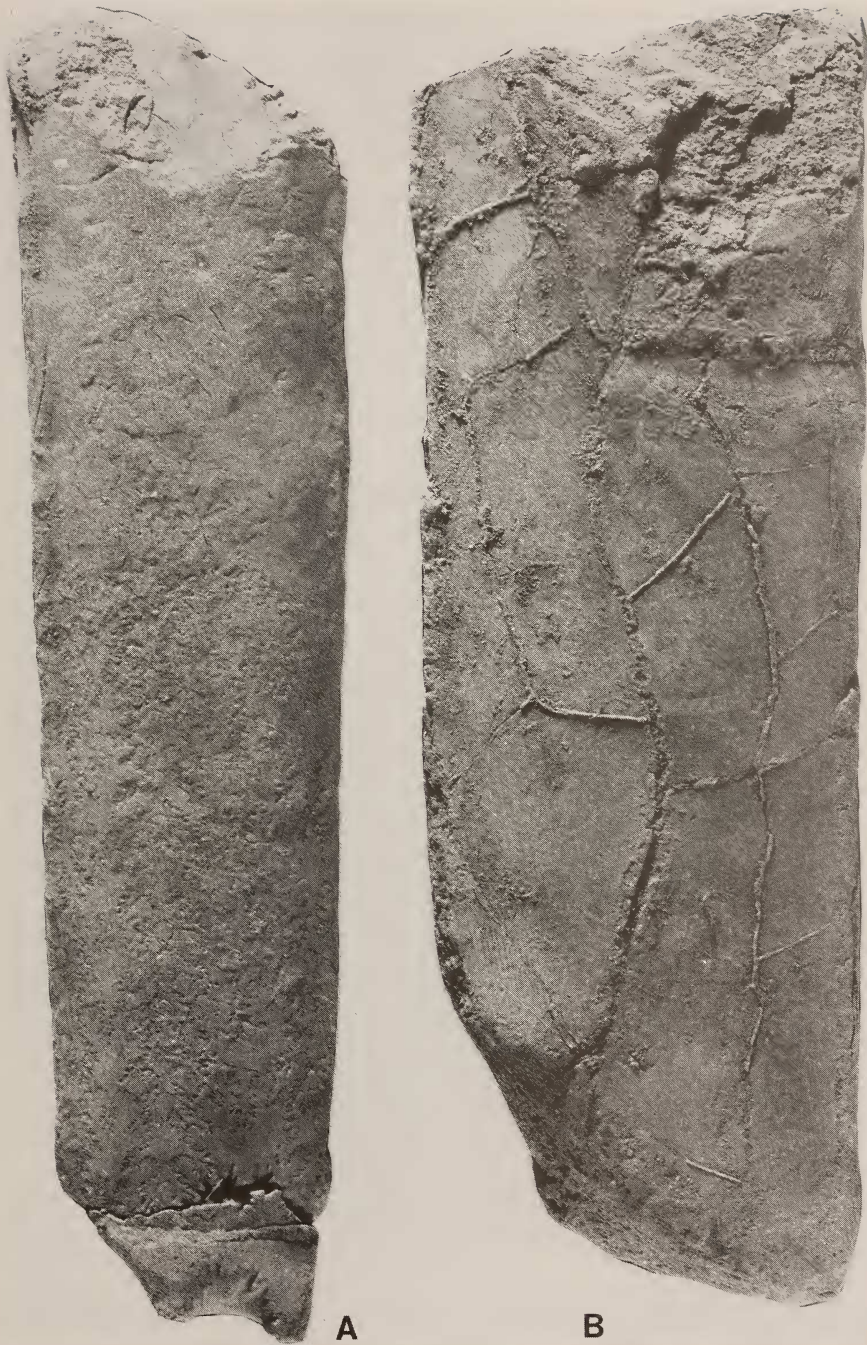


Fig. 53. A. *Eubaculites latecarinatus* (Brunnschweiler, 1966). SAM-PCZ7980 from locality 134, Zululand, St Lucia Fm, Maastrichtian I. B. *Eubaculites simplex* (Kossmat, 1895), SAM-PCZ7980, a body chamber fragment with part of the aperture preserved; from Bed 7 (G) at locality 20, Zululand, St Lucia Fm, Maastrichtian I-II. A. $\times 0,45$; B. $\times 0,70$.



Fig. 54. *Eubaculites simplex* (Kossmat, 1895). A. Large specimen, SAM-PCZ7980 (see also Fig. 53B) showing details of aperture, from Bed 7 (G) at locality 20, St Lucia Fm, Maastrichtian II.

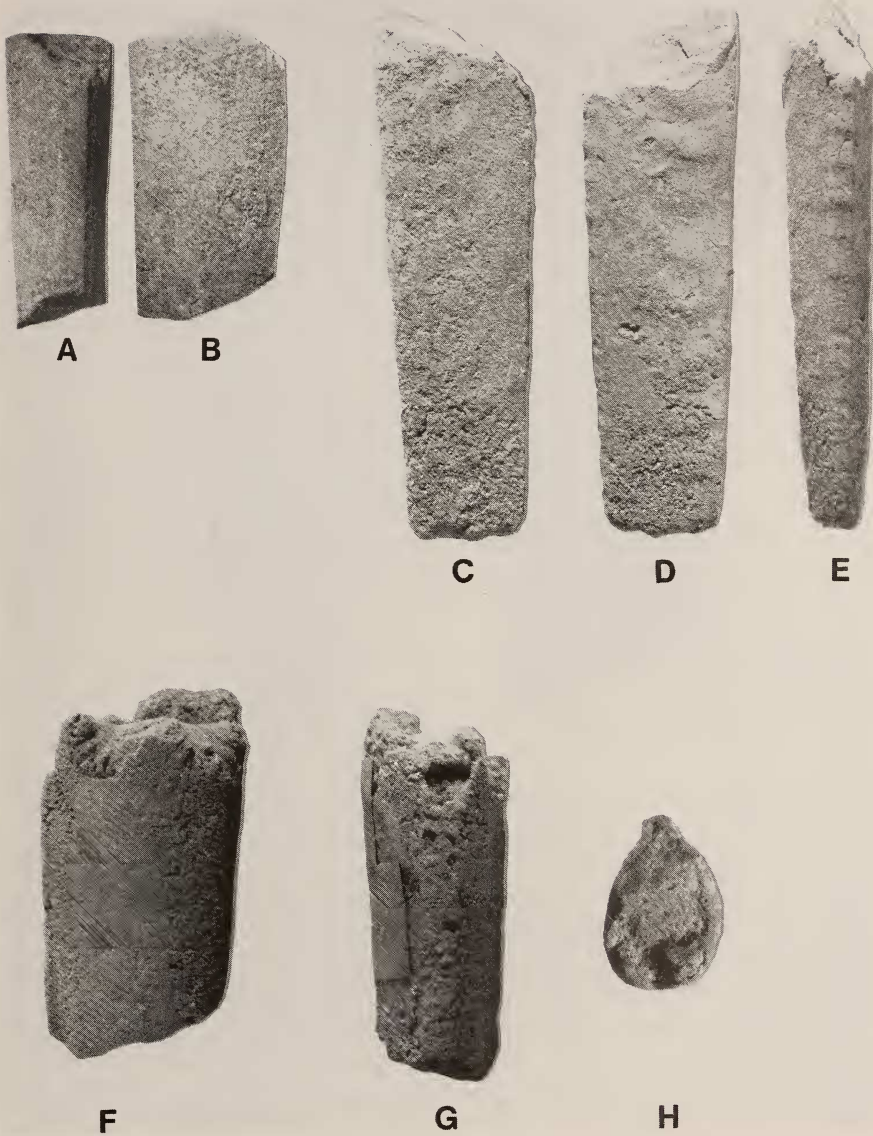


Fig. 55. A-E. *Eubaculites simplex* (Kossmat, 1895). The original of Collignon's (1971, pl. 645 (fig. 2390)) *Baculites occidentalis* from locality 665-7, Route Antsoha-Andranomana (Ambavaloza) (Belo sur Tsiribihina), Madagascar. $\times 1$. C-E. SAS H60A/21, specimen showing transition from fastigate to tabulate venter from locality 133, St Lucia Formation, Maastrichtian II. F-H. *Eubaculites?* sp., specimen from Angola figured by Haas (1943, fig. 16) as *Baculites anceps*. Collections of the American Museum of Natural History, courtesy of Dr N. Eldredge.



Fig. 56. *Eubaculites? binodosus* (Noetling, 1897). Cast of holotype, GSI 3097, of *Baculites binodosus*, the original of Noetling (1897, pl. 23 (fig. 3)) from Dés Valley, Baluchistan.

outcrops in Makakatana Bay, east of the settlement, St Lucia Formation, Maastrichtian I; SAS H60F/5, H60/2, H66F/15, H60F/21, all from Bed F at locality 133; SAS H60A/21 from Bed A; and SAS Z2204 from an unspecified horizon at locality 133; SAS Z2204c and SAS H60HA/21, Bed A, locality 133, cliff section and beach platforms below Charter's Creek Rest Camp, Lake St Lucia, Zululand, St Lucia Formation, Maastrichtian I.

Dimensions

Specimen	Wb	Wh	Wb/Wh	Tapering
SAS H60F/12	9	17	0,53	—
SAS H60/2	9	16	0,56	—
SAS H60F/21	7	16	0,44	—
	12	20	0,60	7,3 (D = 55)
SAS H60F/5	11	24	0,46	—
SAS H163F/2	10	18	0,56	—
SAM-PCZ7939	34	67	0,50	—
SAM-PCZ7912	43	80	0,53	—

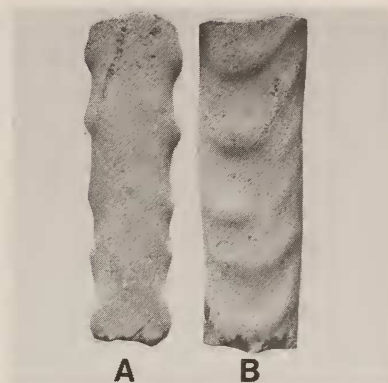


Fig. 57. *Baculites* sp. (nov.?) *aquilaensis* Reeside. The original of Collignon (1970, pl. 639 (fig. 2358)) from the Upper Campanian of locality 227-2, Mokotibe (Antsalova) Madagascar. $\times 1$.

Diagnosis

Compressed *Eubaculites* (Wb/Wh 0,46–0,70) with flanks that are smooth or with broad, faint dorsal undulations. Whorl section tear-shaped to pyriform, with or without a distinct keel, and venter fastigiate or narrowly tabulate.

Description

The lectotype (Fig. 7I–K) as represented by a cast, is 39 mm long, with a maximum preserved whorl height of 19,5 mm and a whorl breadth to height ratio of 0,64. It retains recrystallized shell, and appears to be a fragment of body chamber; venter and dorsum are parallel when viewed in profile. The dorsum is broad and very feebly convex. The dorso-lateral margin is narrowly rounded, the dorsal two-thirds of the flank very broadly rounded, the ventral third converging to a fastigiate venter, demarcated from the flanks by a marked longitudinal depression. There is no ornament. Zululand material referred to this species consists predominantly of fragmentary juvenile specimens. These all show the very compressed whorl section, and have generally no, or extremely weak flank ornament. H60F/21 (Fig. 55C–E) shows the transition from a fastigiate venter at the smaller end to tabulate at the larger. In all the other specimens, the venter is narrowly tabulate both with and without crenulations.

Two large specimens, PCZ7939 (Fig. 51E–F)—part of the phragmocone—and PCZ7980 (Figs 53B, 54A)—part of a body chamber with the aperture preserved, with compressed whorl section—are possibly adults of the species. These indicate that *E. simplex* may reach maximum sizes comparable to those of *E. latecarinatus* and *E. carinatus*.

Discussion

Henderson *et al.* (1992) referred an assemblage of 132 specimens from the Miria Formation of Western Australia to this species. They described the shell as straight or

with a slight endogastric curvature, and a very low expansion rate. The whorl section is fairly to very much compressed, with a whorl breadth to height ratio of 0,46–0,7, the shell surface smooth or with broad, weak undulations on the dorsal part of the flanks, 2–4 in a distance equal to the whorl height. Dorsum and venter are completely smooth. The whorl section is tear-shaped to weakly pyriform, the flanks broadly convex, dorsum feebly convex, and venter fastigiate or with a tabulate keel which may be bordered on either side by a longitudinal groove in some specimens. A collection of 27 specimens from a single locality included eight with a clearly tabulate venter and eight with a rounded to fastigiate venter that is narrowly arched in some but blade-like in others. Two specimens showed a change from fastigiate to tabulate with growth. Shape of venter is not a function of growth stage, as both large (whorl height in excess of 20 mm) and small specimens (whorl height less than 20 mm) may have either tabulate or fastigiate venter.

Patagonian material described by Hünicken (1965) as *Baculites* sp. and possessing a keeled, fastigiate venter, is referred here to *E. simplex*. *Baculites vagina* var. *cazadorianus* Paulcke (1907: 11, pl. 16 (figs 5, 5a, 5b)) may perhaps be conspecific, but its range of variation is not known and the sole illustrated specimen is more like *B. anceps* in whorl profile than *E. simplex*.

The lack of significant flank ornament, very compressed whorls, and fastigiate to very narrowly tabulate venter separates populations of *E. simplex* from *E. vagina*, *E. carinatus* and *E. labyrinthicus*, described above. Smooth variants of *E. carinatus* and *E. labyrinthicus* may be difficult to separate, as individuals, from smooth *E. simplex* with tabulate venter, other than by their wider venters. Populations of *E. simplex* and *E. latecarinatus* can be separated by the presence of individuals with fastigiate venters in the former at a size where *E. latecarinatus* always has a tabulate venter, whereas this species has a much wider venter than morphs of *E. simplex* with a tabulate venter. Differences in whorl section in large specimens of *E. simplex* and *E. latecarinatus* are shown in Figure 50.

Occurrence

Maastrichtian of South India, Western Australia, Patagonia, and Zululand (South Africa). This species does not extend into the highest Maastrichtian.

ACKNOWLEDGEMENTS

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